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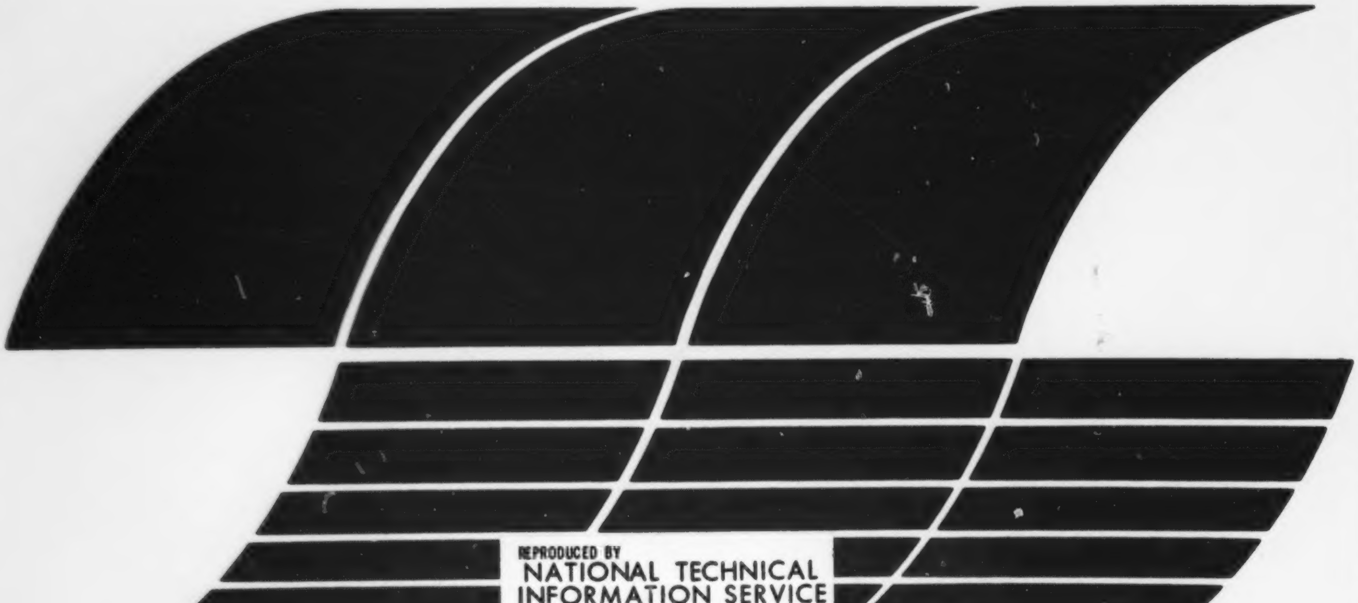
HF Radar Measurements of Circulation in the Eastern Strait of Juan de Fuca (August, 1978)

Interagency Energy/Environment R&D Program Report



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by

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FOREWORD

An understanding of the surface circulation in a partially or fully enclosed marine environment is necessary in order to forecast the effects of an oil spill, pipeline oil leak, or other varieties of floating pollutants. The Wave Propagation Laboratory's program of surface current mapping contributes to this understanding.

In this report we present HF radar observation measurements in the Eastern Strait of Juan de Fuca for a four day period. The hourly measurements give surface currents at 1.2 km intervals. We have estimated the mean surface flow and the semi- and diurnal-components of tidal currents. The current maps demonstrate the extreme complexity of the surface circulation and represent an important advance in understanding the physical oceanography of this complicated, ecologically-sensitive region.

Donald E Barrick

Donald E. Barrick
Chief
Sea State Studies
Wave Propagation Laboratory

ABSTRACT

During August, 1978, the surface currents in the Eastern Strait of Juan de Fuca were mapped with a High Frequency (HF) radar system (CODAR). The surface currents were measured simultaneously over several hundred square kilometers at one hour intervals continuously for five days. Strong tidal currents, estuarine flow, and wind driven circulation were all identified as influential forces in the strait. These measurements were compared with those obtained with surface drifters and current meters, which were observed by the other participants in this experiment. The radar and current-meter measured currents generally were in agreement to within a few centimeters per second. Similarly, the radar-predicted trajectories usually followed the drifter tracks closely, i.e., within a couple of kilometers over many hours. On one day, a transient reversal in the estuary flow (due to major wind forcing off the Pacific Coast of Washington) was identified by the radar, current meter, and drifter observations.

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SECTION 1

INTRODUCTION

During the summer of 1978, the Sea State Studies Group* participated in a joint oceanographic experiment with the Pacific Marine Environmental Laboratory (PMEL/NOAA), Evans-Hamilton, Inc., and the Canadian Institute of Ocean Sciences (IOS). This experiment was designed to help improve our knowledge of the circulation in the Eastern Strait of Juan de Fuca and its influence on a possible oil spill. Both oceanographic and meteorological data were collected over a period of several days using conventional instruments and an HF radar system (CODAR)† that remotely measures ocean surface currents. Several moored current meter strings were deployed by PMEL in the same area covered by the radar, while Evans-Hamilton, Inc. tracked dozens of surface drift sheets using aircraft with mini-ranger positioning. IOS tracked surface drifters farther west in the Strait of Juan de Fuca and near Haro Strait. Although the IOS measurements fell in a region apart from the rest of the participants, they provided a more complete picture of the flow patterns in this intricate system of islands and estuaries.

CODAR was used to map surface current velocities simultaneously at several hundred locations across this area. These "snapshots" of the current field are especially important in resolving spatial circulation patterns as well as temporal variations due to tides and winds. In this way, the horizontal current structures can be examined and correlated with the complicated bathymetry and coastal topography. The diverse measurements made here complement rather than duplicate one another. For example, the surface drifters were driven by surface currents which were influenced by local winds. The current meters, however, were positioned several meters below the surface and, therefore, did not measure the full effects of transient winds at the water surface. These current-meter measurements reflect the tidal flow, runoff, and major wind forcing. The surface drifters were also used to simulate the Lagrangian trajectories along which spilled oil might move; the current meters were used to measure the Eulerian velocity at fixed locations.

The HF radar introduces another dimension to this problem since it makes it possible to obtain both the Lagrangian and the Eulerian descriptions simultaneously. Even though the radar system maps the currents continuously at many locations over a large area, these measurements should not be considered a substitute for the other kinds of measurements. First, the radar provides a spatial resolution on the order of a couple of kilometers; therefore, the detailed location of frontal zones or other boundaries is not possible. Second, the diffusion of oil and floating detritus due to current turbulence and wave action may not be measurable except with several closely spaced drifters. Third, the radar measures the current within the top meter of the ocean, so that deep flowing currents may go undetected unless they affect the surface circulation as well.

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* Wave Propagation Laboratory (WPL), National Oceanic and Atmospheric Administration (NOAA), U.S. Dept. of Commerce, 325 Broadway, Boulder, Colorado, 80303.

† CODAR is a High Frequency (HF) Doppler radar system developed by NOAA (Barrick et al., 1977).

SECTION 2

CONCLUSIONS

The results presented here illustrate a circulation pattern in the Eastern Strait of Juan de Fuca that contains a great deal of spatial detail and temporal variability. The estuarine circulation (gravitational convection) and sea level fluctuations at tidal frequencies are the main driving forces which dominate this important area. However, seasonal and transient winds were significant in determining the currents, especially in the near surface layer. All of these phenomena have been identified as important agents during this four day experiment.

HF radar (CODAR) provides a unique time sequence of real maps that permit spatial and temporal features to be easily resolved. Bathymetric influences are evident and can be related to shear zones and fronts. Both the Lagrangian and the Eulerian characteristics of the flow can be resolved so that it is possible to compute the movement of oil slicks and the magnitude of runoff and tides. Current meters and drifters supply greater space and time resolution than HF radar for certain kinds of studies. The radar presently can provide a spatial resolution of about ten square kilometers and a temporal resolution of about ten minutes. These resolution limits are set by the present data processing methods. Experiments such as this help to improve these methods and, thus, the accuracy of the radar technique.

SECTION 3

RECOMMENDATIONS

This report presents examples of the circulation in the Eastern Strait of Juan de Fuca as remotely measured by CODAR. Comparisons of these measurements with surface-drifter and moored-current-meter observations show very good agreement. These results indicate that this radar system may be very useful as either an operational tool or a research instrument. It can be used to compute the trajectories that oil may follow in a future tanker spill or pipeline leak. This capability is especially helpful in assessing the hypothetical impact upon the environment and ecology. It could also be of assistance in directing clean-up operations after an oil spill or in designing adequate safeguards in anticipation of future problems. The research potential of CODAR is also far-reaching. CODAR can be used to measure the currents caused by various physical forces such as winds, tides, run-off, etc. Our understanding of the circulation in a particular area is thus improved and our ability to manage the resources in that area are thereby enhanced.

It is recommended that the on-going development of CODAR be directed towards improving its accuracy and reliability (which already meet or exceed those of other instruments such as surface drifters) in order to better accomplish these tasks. This radar system offers remote measurements of current simultaneously over large areas and continuously over many days at relatively low operating costs. Using existing data sets, the projected goals for next year are to obtain: (1) a surface current velocity with standard deviation of 5 cm/s or better, and (2) a surface trajectory position accuracy of 1 km after 24 hours. While CODAR offers many advantages over existing, more conventional instruments, it cannot always be substituted for them. In particular, moored current meters measure the subsurface currents at depths that are not probed by the radar. Both tools provide a powerful combination in cases where the vertical structure of circulation is important and needs to be studied. Surface drifters can be invaluable for examining frontal zones and shear boundaries where fine spatial resolution (hundreds of meters) is important. Several drifters closely spaced may extract features more precisely than the radar. Towards this end we are presently developing a radar transponder package that can be deployed in inexpensive and expendable drifter packages. Thus, a variation of the CODAR system will provide economical drifter tracking capability with improved reliability.

SECTION 4

RADAR OPERATION

During August 1978, two CODAR units were deployed at the Eastern Strait of Juan de Fuca in order to remotely measure surface currents. One unit operated continuously from Dungeness Spit for nearly 115 hours, while the other unit operated first from Point Wilson for 73 hours and then Ediz Hook, for 28 hours. The locations of these radar sites and the principal regions mapped are shown in Fig. 1, and the dates and times when data were collected are given in Fig. 2. Radar sea-echo data were collected for the first 36 minutes of each hour. All times are Pacific Daylight Time (PDT). These 36-minute sea-echo records provided a velocity resolution of better than 1 cm/s, although the data may not be meaningful to better than 5 to 10 cm/s. The radar measures the phase velocity of a six-meter ocean wave which is shifted by currents which may be present. This phase velocity is also affected by dynamic wave action relative to the surface current, limiting the accuracy of the radar-measured currents to a few centimeters per second (Barrick and Weber, 1977 and Weber and Barrick, 1977).

SELECTED CURRENT MAPS

Maps of surface current are given at one-hour intervals in the Appendix and are also available on magnetic data tape*. These maps (Figs. A1.00 - A1.71) span the time period from 2100 (PDT) on 22 August 1978 to 2000 on 25 August 1978 for the Dungeness Spit/Point Wilson radar site combination.

Occasionally, there is an area that has no current vectors within it. This is due to our not computing a vector at that location if the signal strength was too low. Also, the maps in Figs. A2.00 - A2.26 cover the time period from 1300 on 26 August 1978 to 1500 on 27 August 1978 for the Dungeness Spit/Ediz Hook site pair. A sample of each set is shown in Fig. 3(a) and 3(b) respectively. These maps represent the surface currents as measured by the radar and, therefore, include the composite effects of tides, winds, runoff, etc. As the maps indicate, the flow is quite complex, and is influenced by varying meteorological conditions (see Fig. 4) and a precipitous bathymetry. The dominant flow patterns are due to the tides which periodically flood and ebb in the area at regular and known intervals. The largest velocities were observed in the vicinity of Admiralty Inlet which opens into the Puget Sound basin to the south.

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* These are 9 track, ANSI compatible magnetic tapes written at 1600 CPI with phase encoding on a Digital Equipment Corporation PDP-11 computer using RSX11M software. Each map is contained in a separate file with a header that explains the contents of that file.

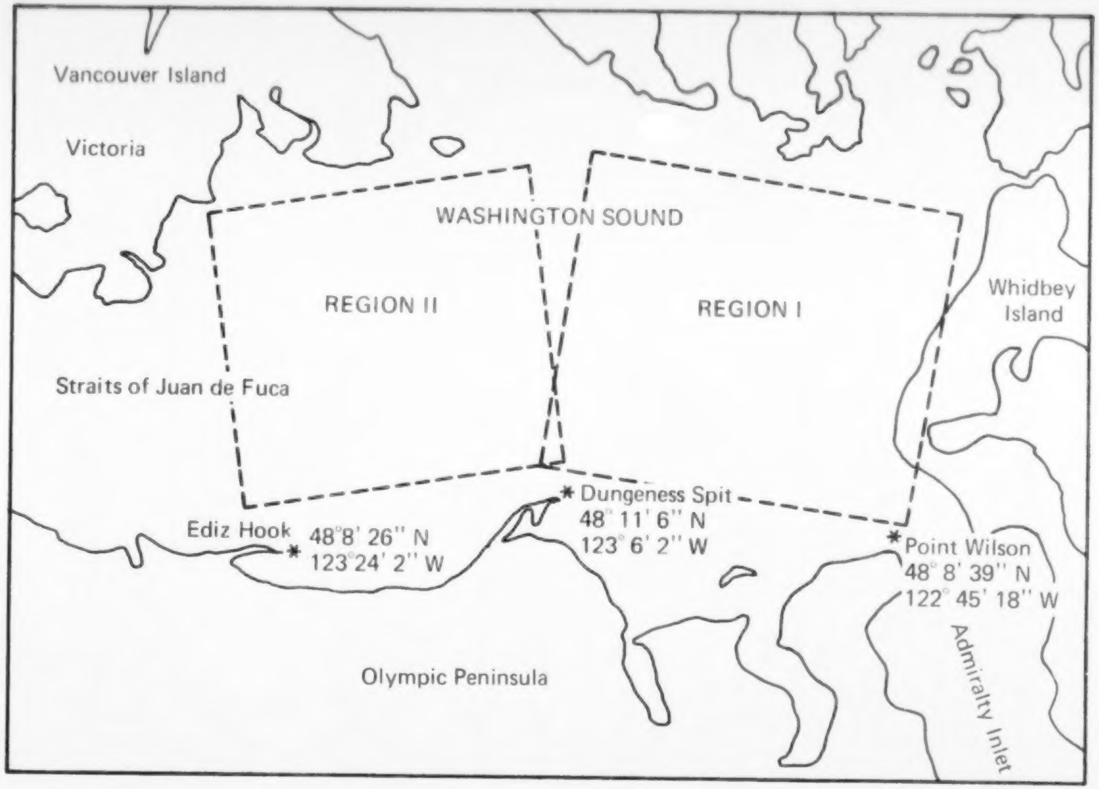
Vancouver Island
Victoria
Straits of Juan de Fuca
WASHINGTON SOUND
REGION II
REGION I
Whidbey Island
Ediz Hook
48°8' 26'' N
123°24' 2'' W
Dungeness Spit
48° 11' 6'' N
123° 6' 2'' W
Point Wilson
48° 8' 39'' N
122° 45' 18'' W
Olympic Peninsula
Admiralty Inlet

FIGURE 1. The two radar units were operated from the three indicated sites at Dungeness Spit, Point Wilson, and Ediz Hook. Region I is the main area mapped with the Dungeness Spit/Point Wilson site combination and Region II is the principal area mapped with the Dungeness Spit/Ediz Hook site combination. The latitude and longitude of each of the sites is given next to each of the site symbols.

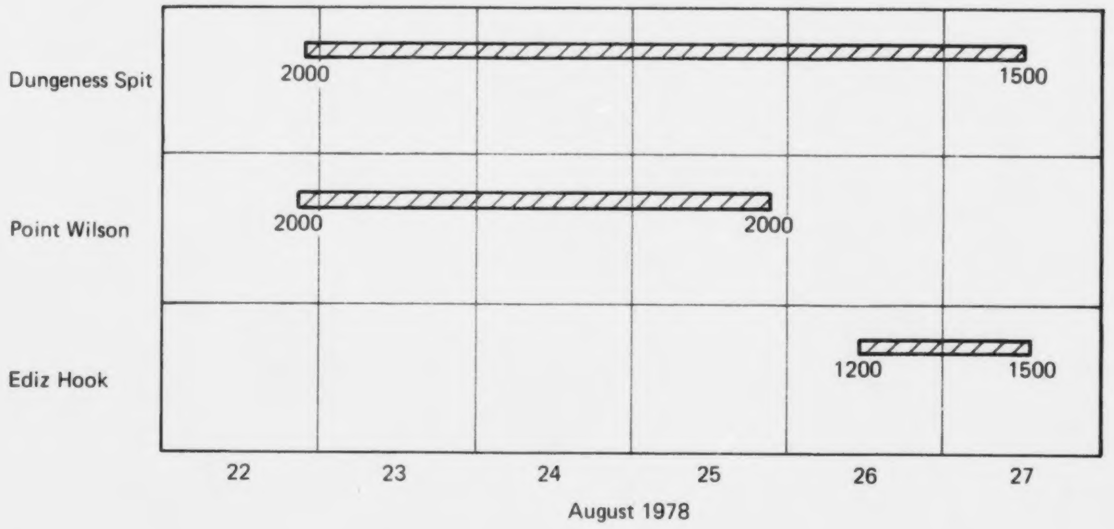

FIGURE 2. Two HF Doppler radar units were operated between 22 and 27 August 1978. One unit operated at the Dungeness Spit site uninterrupted throughout the period. The other unit operated successively from the Point Wilson and Ediz Hook sites. All data collection commenced on the hour (PDT), every hour and continued for 36 minutes.

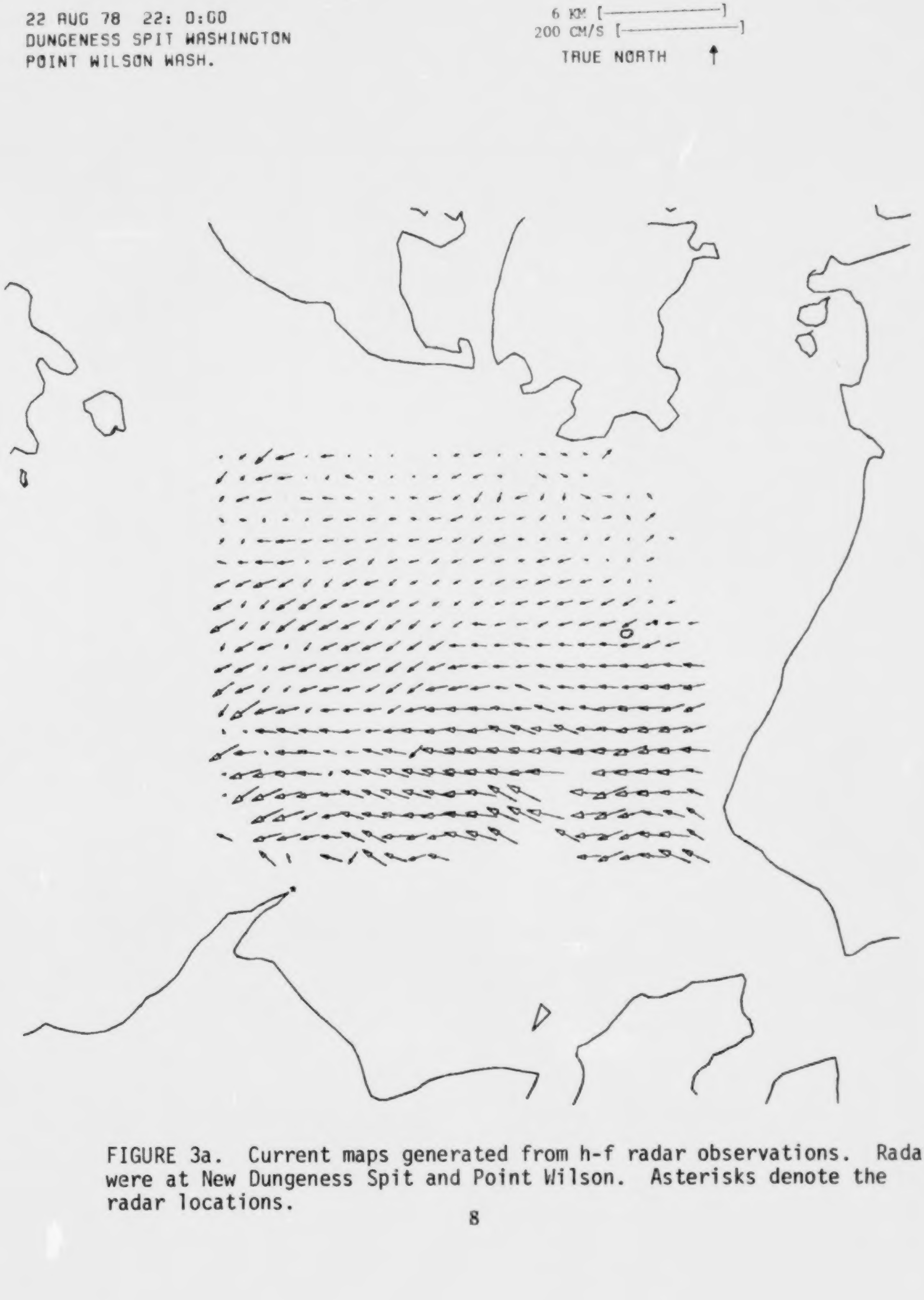
22 AUG 78 22: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.
6 KM [——]
200 CM/S [——]
TRUE NORTH ↑

FIGURE 3a. Current maps generated from h-f radar observations. Radars were at New Dungeness Spit and Point Wilson. Asterisks denote the radar locations.

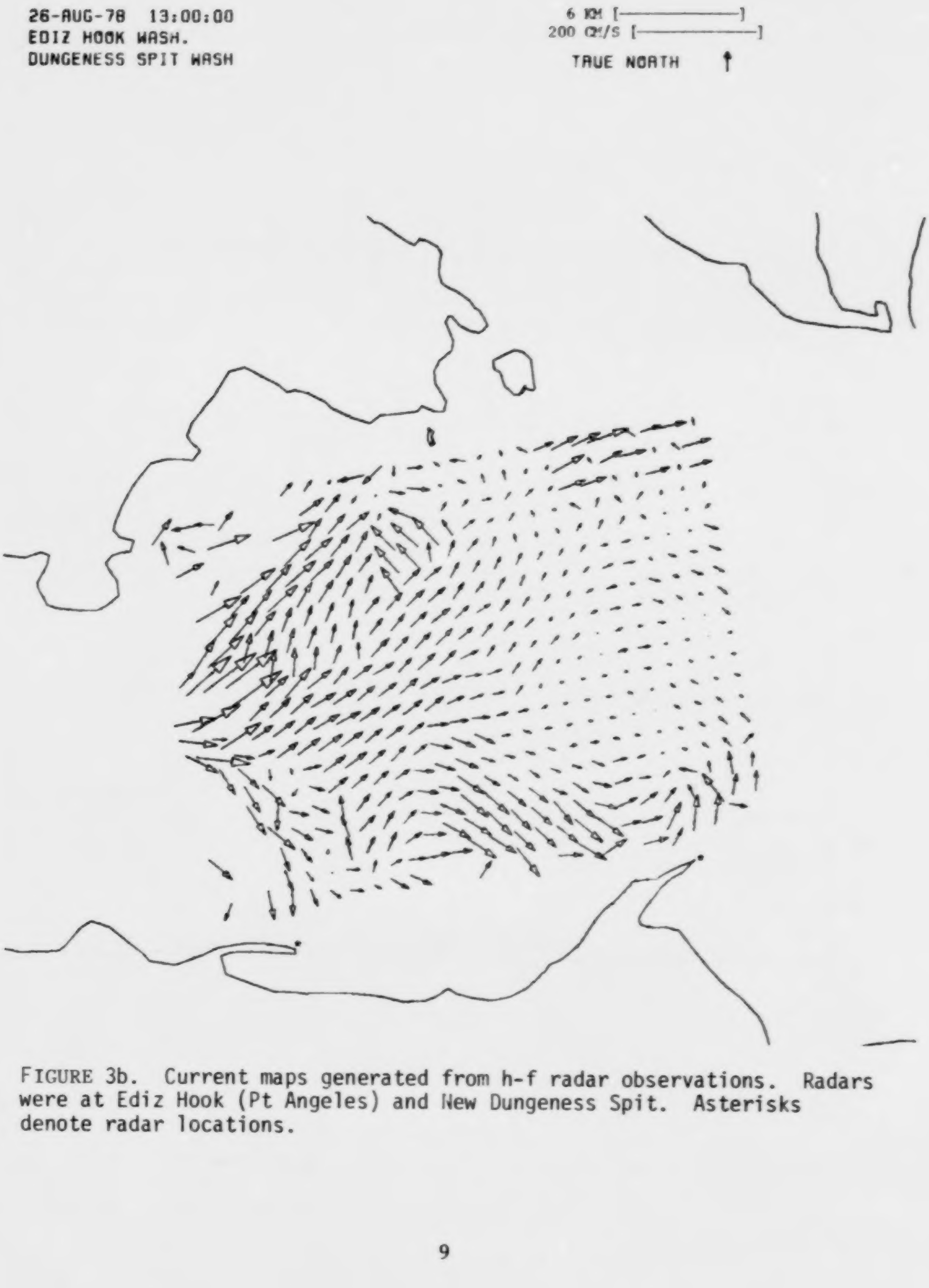
26-AUG-78 13:00:00
EDIZ HOOK WASH.
DUNGENESS SPIT WASH
6 KM [ ]
200 CM/S [ ]
TRUE NORTH

FIGURE 3b. Current maps generated from h-f radar observations. Radars were at Ediz Hook (Pt Angeles) and New Dungeness Spit. Asterisks denote radar locations.

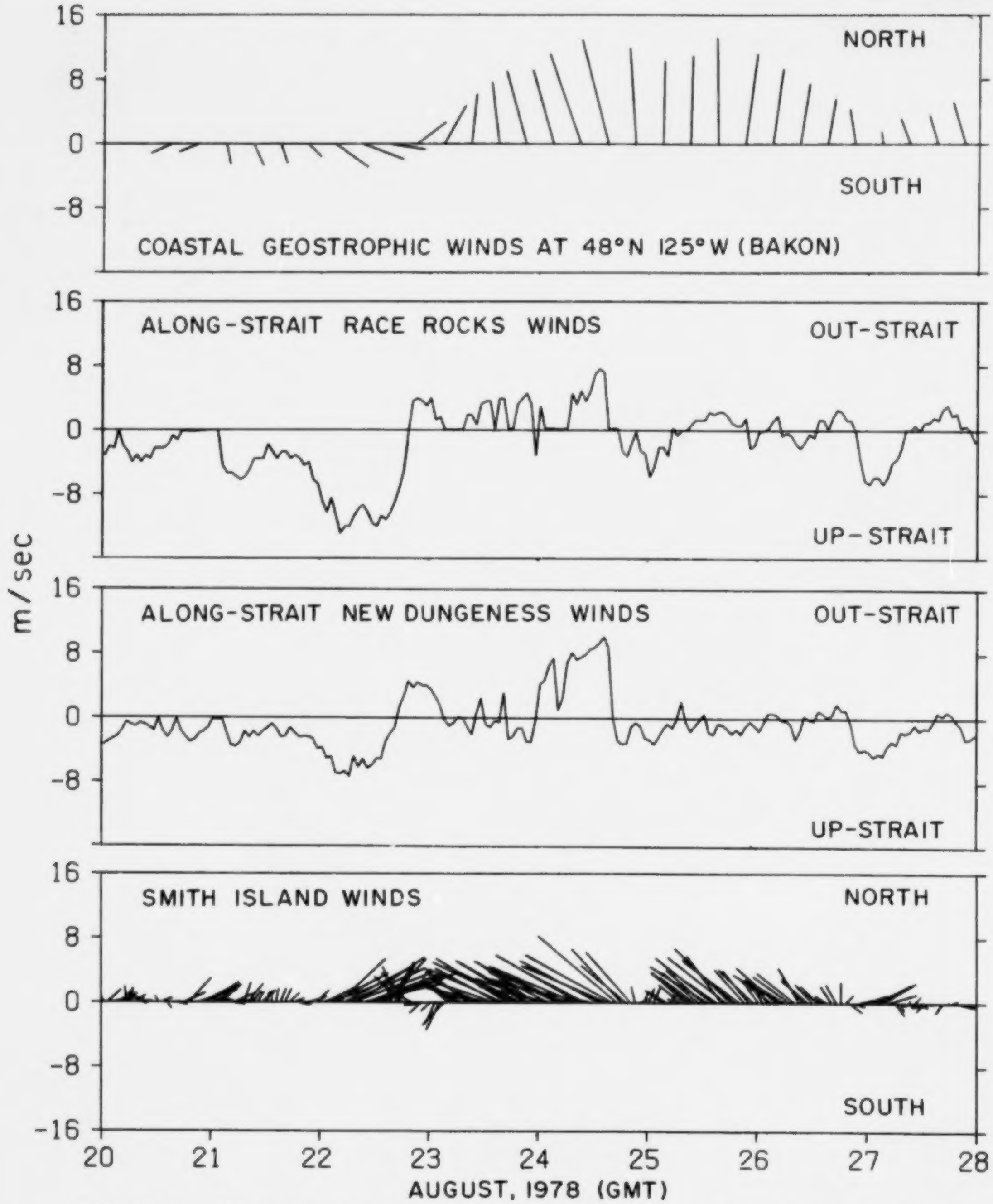

FIGURE 4. Wind measurements at various locations for the time of the experiment. The stick diagrams are vector plots, each line represents speed and direction. The others are the speed component in the dominant direction.

These maps reveal that a westward (seaward) net surface flow prevailed throughout the Strait of Juan de Fuca. This flow is primarily driven by a longitudinal sea surface slope and internal pressure gradients maintained by the river discharge into the system. This seaward flow is the surface manifestation of a vigorous, two-layer estuarine circulation that dominates the entire Strait of Juan de Fuca (Cannon, 1978). The maps of the area farther west in the strait show a transient phenomenon which may be characterized by a west-to-east reversal in the near-surface flow. This reversal was generated by winds out of the southwest off the Pacific Coast of Washington which caused an accumulation of less dense water at the strait entrance. This less dense water then slowly propagated up the strait (in a southeast direction) as a gravity current which dramatically modified the surface estuarine flow (Holbrook and Muench, 1980; Holbrook and Frisch, 1979).

The mean (estuarine) flow is illustrated in the next five figures 5.00-5.04. The first figure (5.00) presents a 24-hour mean for the eastern end of the strait beginning with data at 2018 on 22 August 78. The next two figures (5.01 - 5.02) give the net flow for the next two consecutive 24-hour periods. All three maps show the same general flow westward at a rate of 20-40 cm/s. The differences from day to day are due to longer-period phenomena such as tides with periods exceeding many days and seasonal wind driven circulation. Figure 5.03 is the mean flow for the entire 3-day period. The last figure (5.04) is the 24-hour mean flow farther west between Port Angeles and New Dungeness Spit. The transient current reversal mentioned above is clearly evident where the eastward moving current tends to deflect the seaward flowing water to the south near its front. Note the eastward recirculation pattern north of New Dungeness Spit.

THE TIDES

Only two of the tidal constituents could be resolved with the short data records collected during this experiment. We computed the two dominate tidal components (diurnal and semi-diurnal) by least squares fitting sine and cosine terms to the time-series data for each position on the water. Maps of the first component*, with a period of 12.3 hours, are presented in Figs. 6.00 - 6.04. Figure 6.00 shows the M2 tidal ellipses derived from 24 hours of data beginning at 2018, 22 August 1978 for Region I (Fig. 1). Figures 6.01 - 6.02 give the M2 tidal ellipses for the 24-hour periods beginning at the times given in the figures. The fourth figure (6.03) gives these tidal ellipses based on all three days of data. Although these tidal - ellipse charts are all very similar in appearance, the differences are due to the other tidal components and long-term phenomena that are aliased into the data. Even though we cannot precisely measure the tidal spectrum with such a short data set, these ellipse diagrams suggest important day-to-day variations in the circulation. The last figure (6.04) gives these tidal ellipses for Region II beginning with data at 1220 on 26 August 1978. Undesirable

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* We shall call this component M2 although it is really a combination of several tidal components. Its period was derived by taking a weighted average of the frequencies of all components.

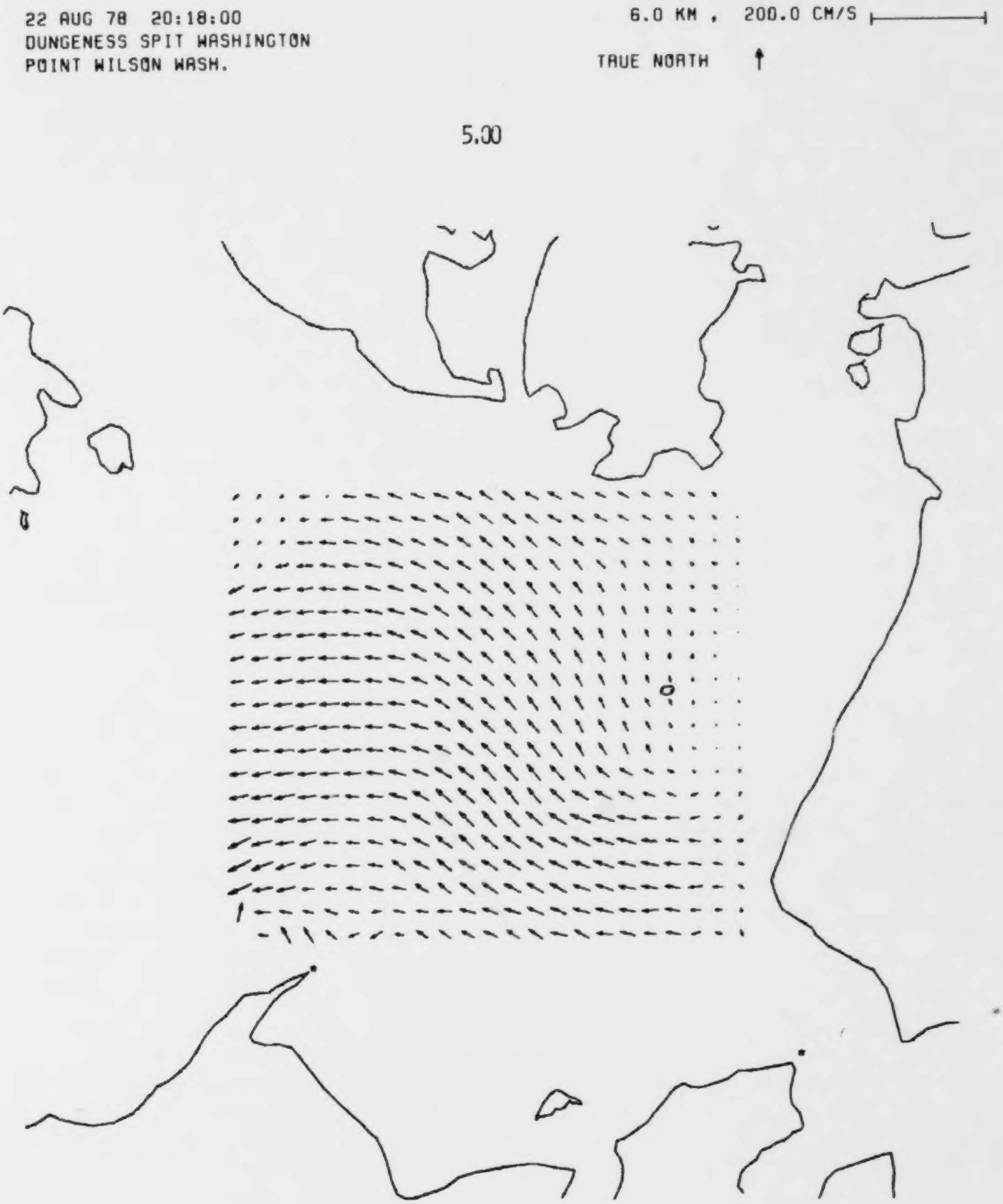
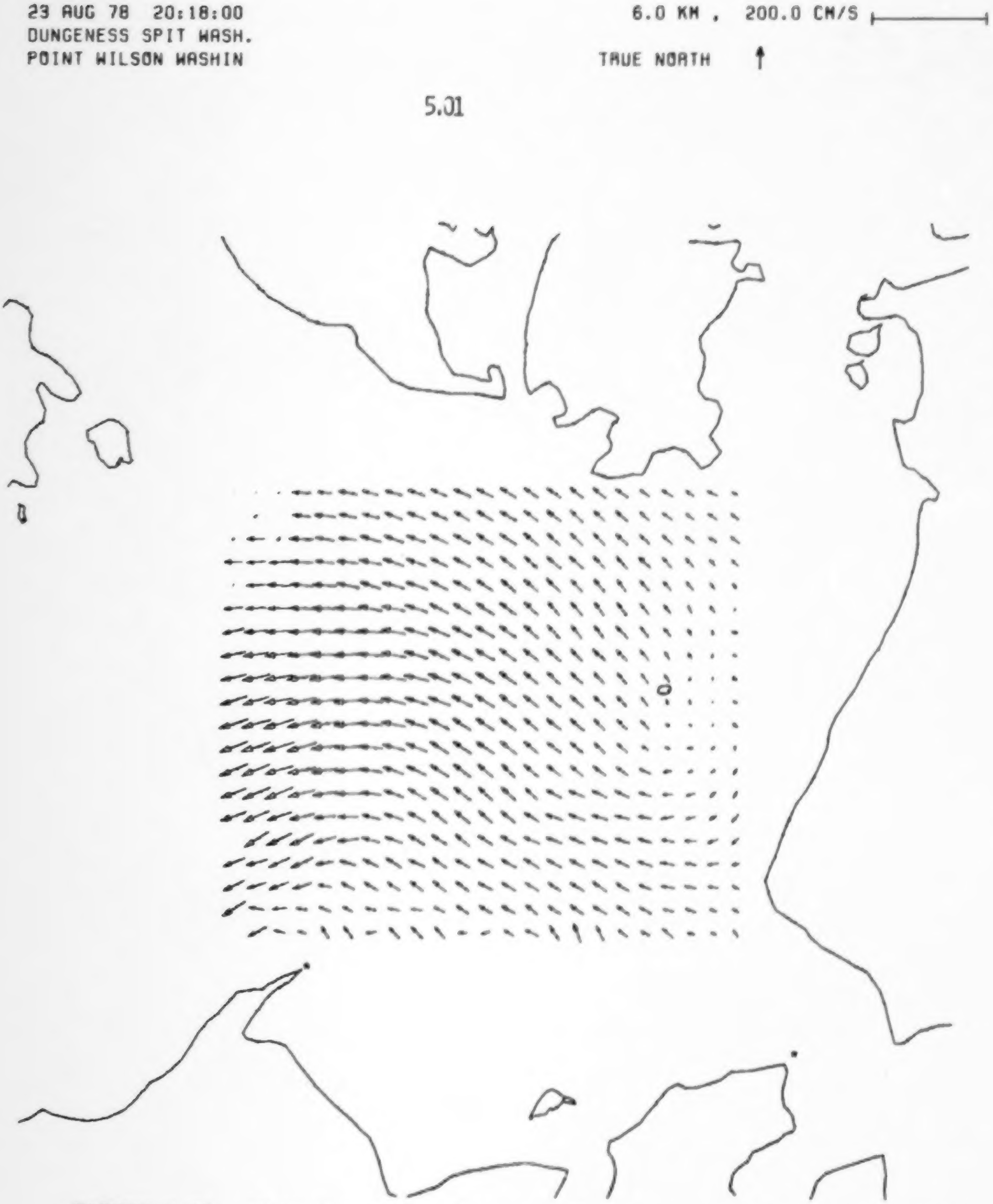

22 AUG 78 20:18:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.
6.0 KM , 200.0 CM/S
TRUE NORTH
5.00

FIGURE 5.00. This map shows the mean flow for starting times indicated in the upper left hand corner. It represents a 24-hour mean.

5.01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DUNGENESS SPIT WASH.
POINT WILSON WASHIN
6.0 KM , 200.0 CM/S
TRUE NORTH

FIGURE 5.01. This map shows the mean flow for starting times indicated in the upper left hand corner and represents a 24-hour mean.

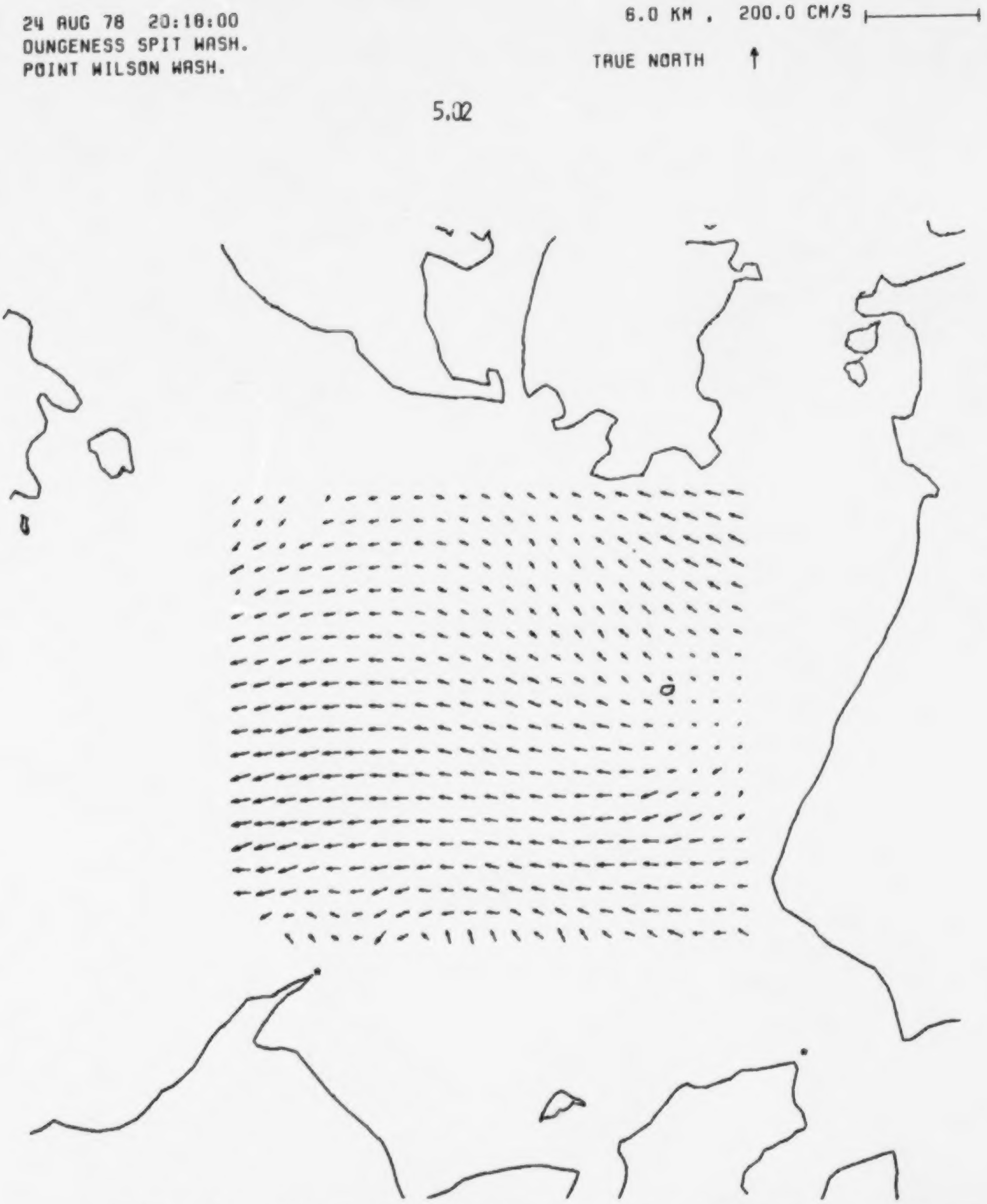

24 AUG 78 20:18:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.
6.0 KM , 200.0 CM/S
TRUE NORTH
5.02

FIGURE 5.02. This map shows the mean flow for starting times indicated in the upper left hand corner and represents a 24-hour mean.

5.03

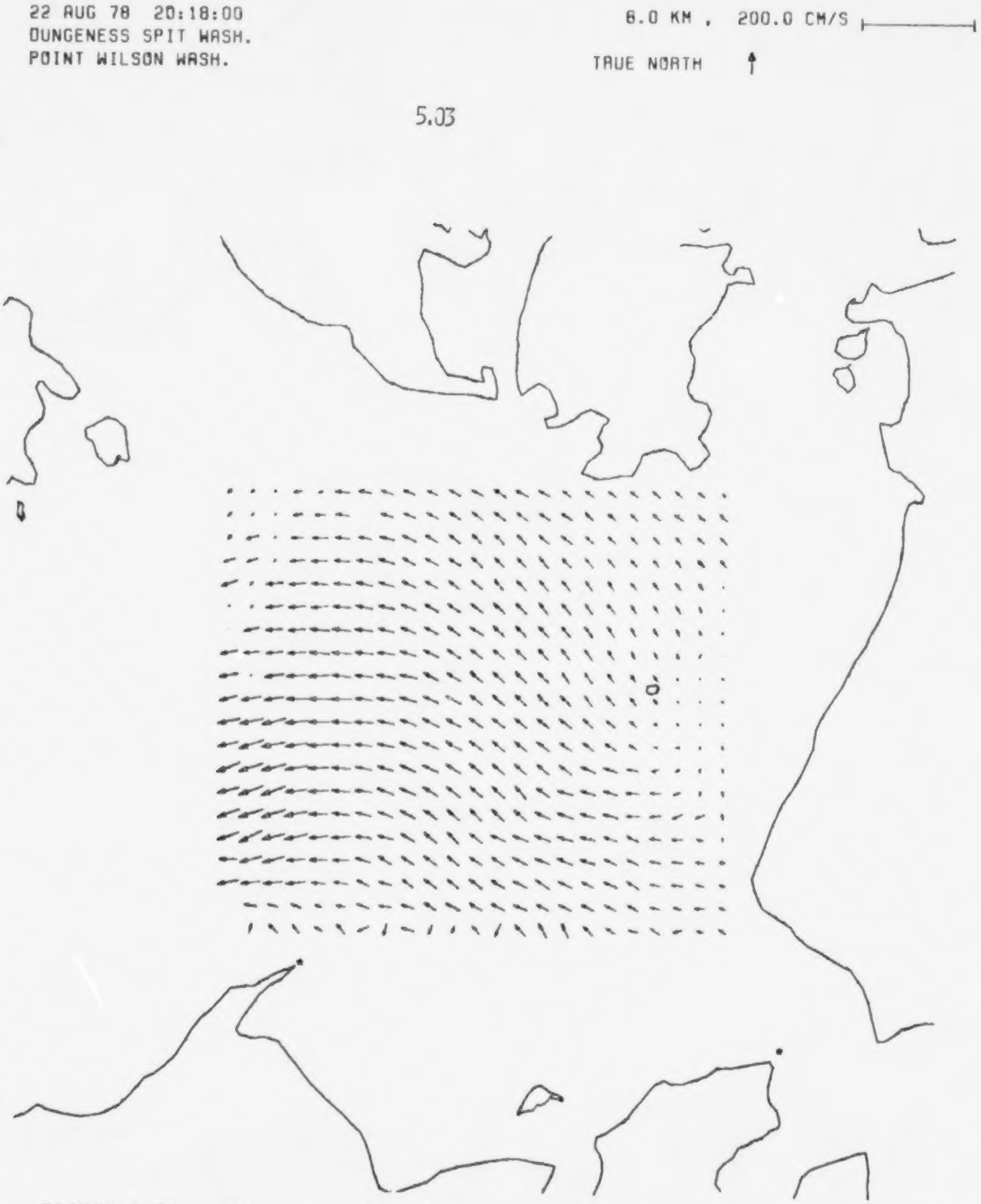

22 AUG 78 20:18:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.
6.0 KM , 200.0 CM/S
TRUE NORTH

FIGURE 5.03. This map shows the mean flow for starting times indicated in the upper left hand corner and represents a 3-day mean.

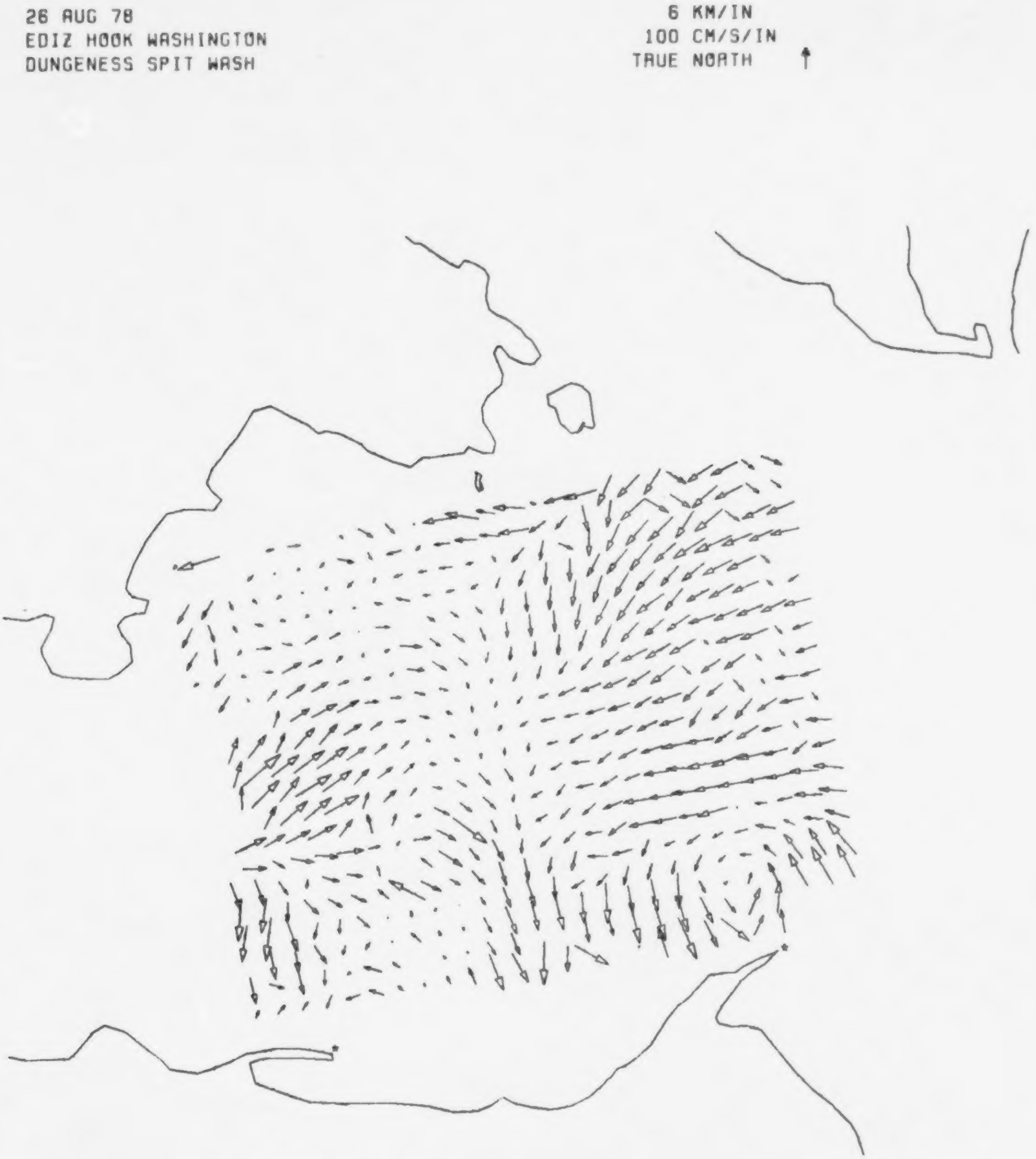

26 AUG 78
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH
6 KM/IN
100 CM/S/IN
TRUE NORTH ↑

FIGURE 5.04. This map shows the mean flow for starting times indicated in the upper left hand corner and represents a 24-hour mean.

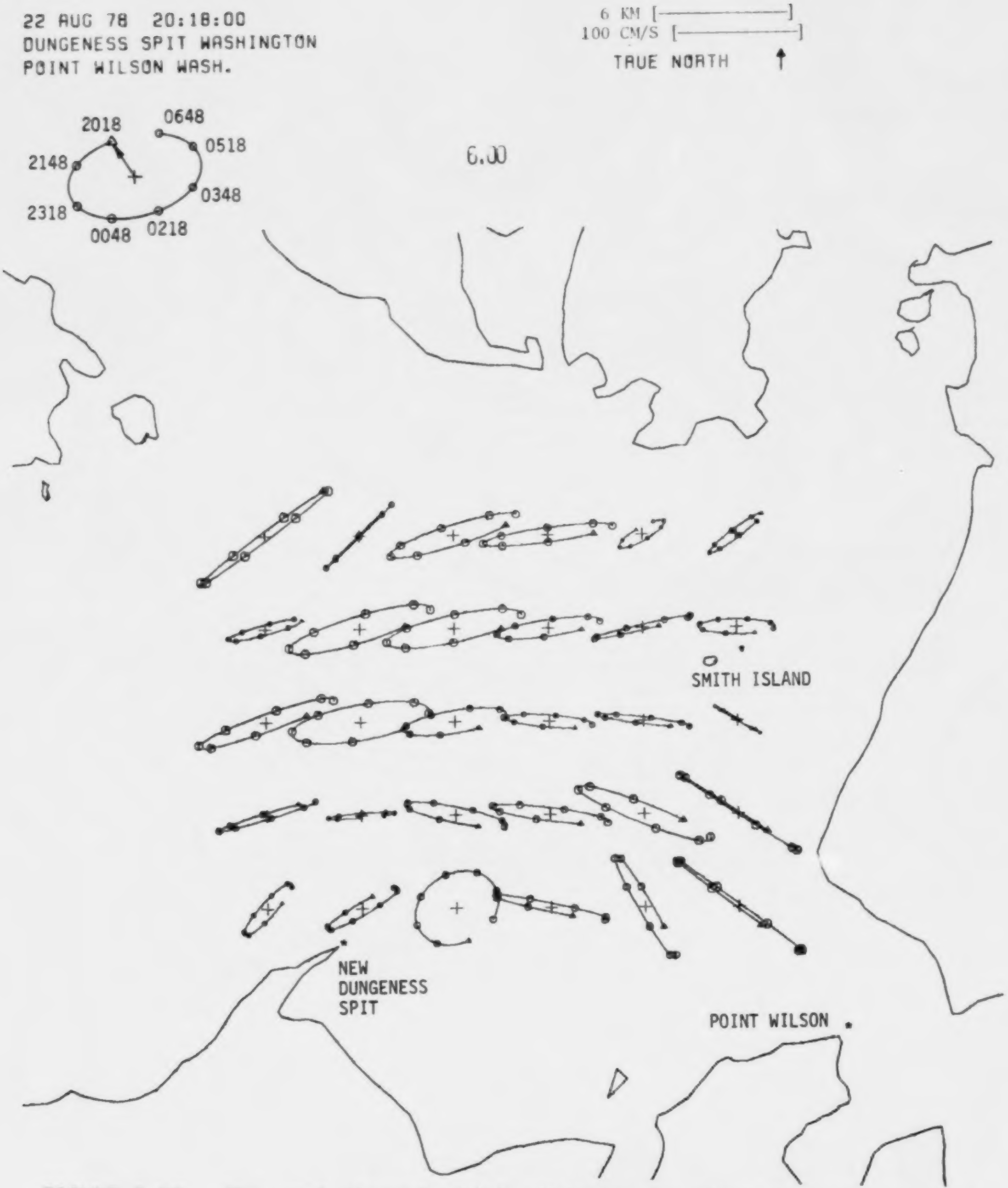
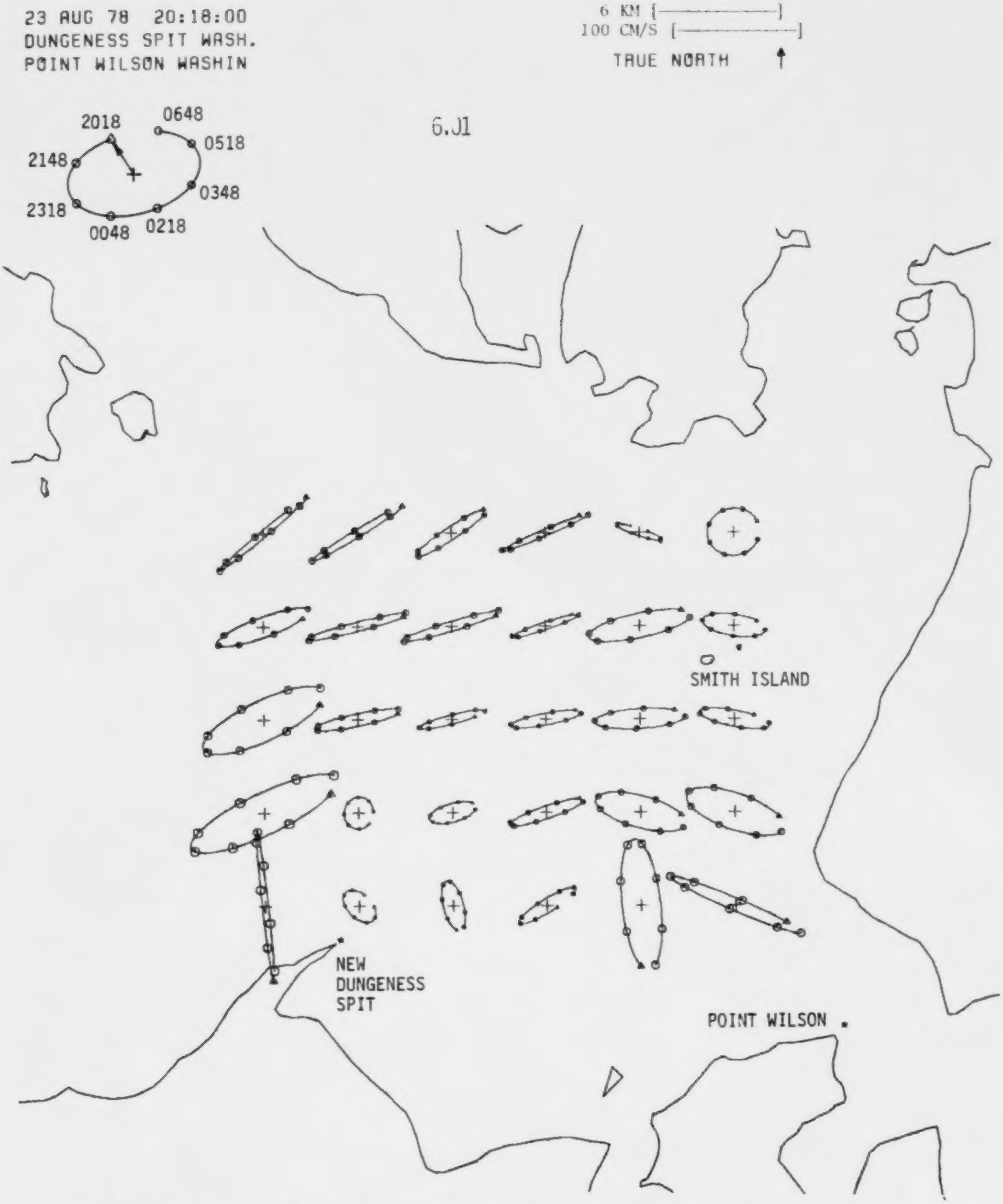

22 AUG 78 20:18:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.
6 KM
100 CM/S
TRUE NORTH
2018
0648
0518
2148
0348
2318
0048
0218
6.00
SMITH ISLAND
NEW
DUNGENESS
SPIT
POINT WILSON

FIGURE 6.00. The semi-diurnal tidal ellipses are given for part of the Eastern Straits of Juan de Fuca. The triangle symbol marks the starting point for the ellipse at the time 2018, 22 August 1978. These are based on 24 hours of data beginning at this time. The magnitude and the direction of the current can be determined for a particular time by starting the origin of the current arrow at the center of the ellipse, the magnitude and direction will be given by the time location on the ellipse.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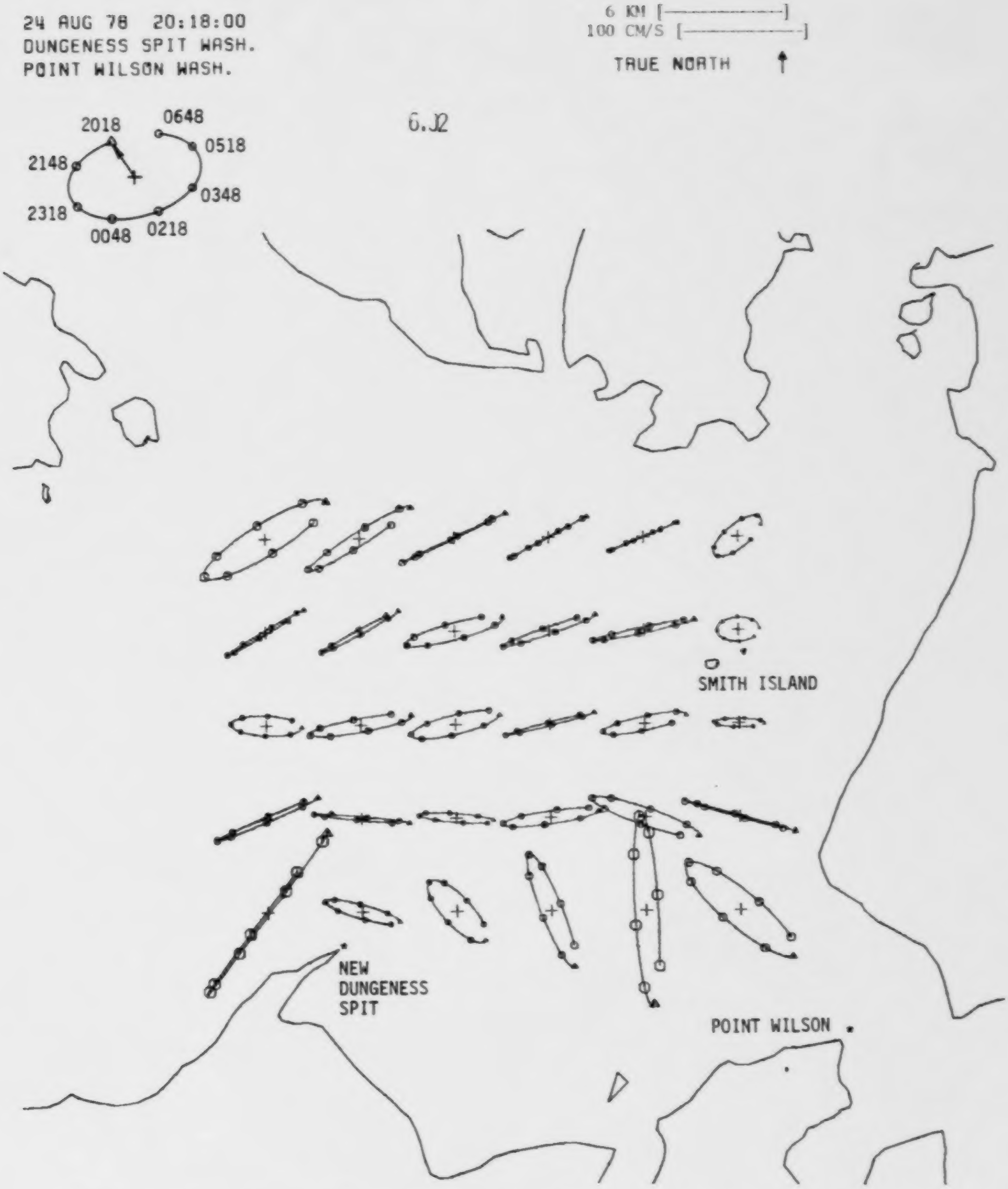
POINT WILSON WASHIN
6 KM
100 CM/S
TRUE NORTH
6.01
2018
0648
0518
2148
0348
2318
0048
0218
SMITH ISLAND
NEW
DUNGENESS
SPIT
POINT WILSON

FIGURE 6.01. The semi-diurnal tidal ellipses are given for part of the Eastern Strait of Juan de Fuca. The triangle symbol marks the starting point for the ellipse at the time 2018, 23 Aug 78.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POINT WILSON WASH.
6 KM
100 CM/S
TRUE NORTH
6.02
2018
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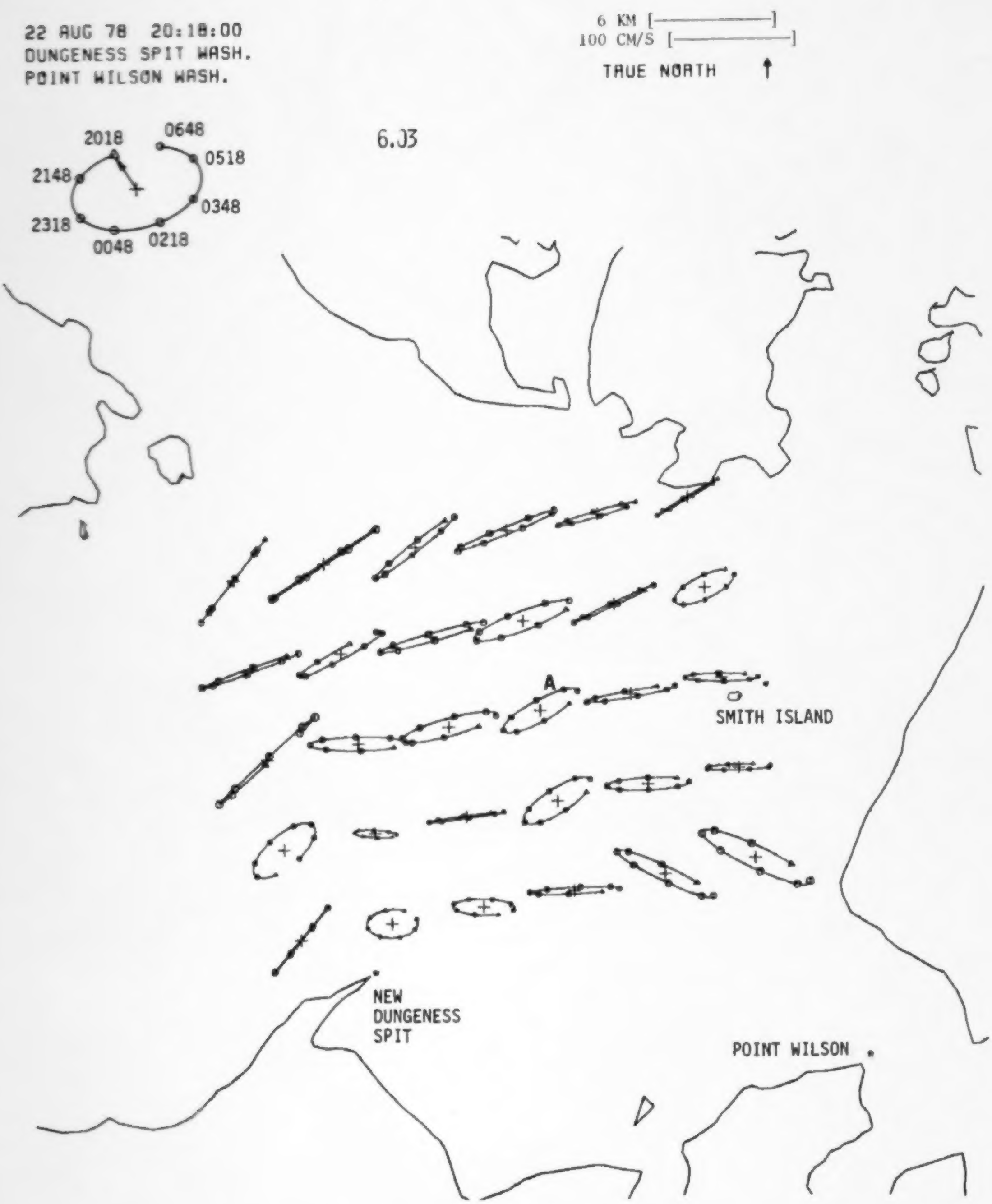
SMITH ISLAND
NEW DUNGENESS SPIT
POINT WILSON

FIGURE 6.02. The semi-diurnal tidal ellipses are given for part of the Eastern Strait of Juan de Fuca. The triangle symbol marks the starting point for the ellipse at the time 2018, 24 August 1978.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POINT WILSON WASH.
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NEW DUNGENESS SPIT
POINT WILSON

FIGURE 6.03. The semi-diurnal tidal ellipses are given for part of the Eastern Strait of Juan de Fuca. The triangle symbol marks the starting point for the ellipse at the time 2018, 22 August 1978. These are based upon 72 hours of data beginning at this time.

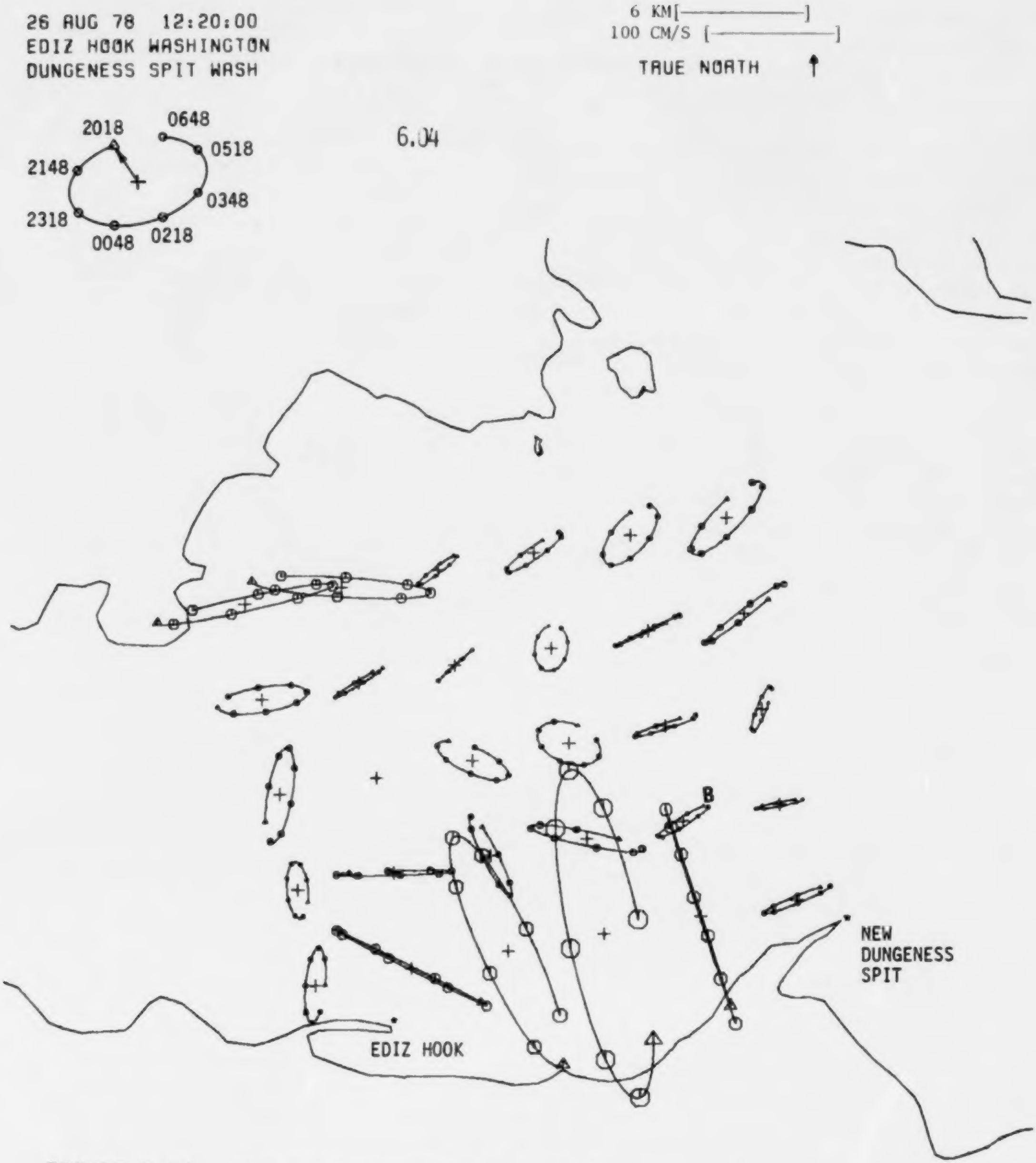
26 AUG 78 12:20:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH
6 KM
100 CM/S
TRUE NORTH
6.04
2018
0648
0518
2148
0348
2318
0048
0218
B
NEW DUNGENESS SPIT
EDIZ HOOK

FIGURE 6.04. The semi-diurnal tidal ellipses are given for part of the Eastern Strait of Juan de Fuca. The triangle symbol marks the starting point for the ellipse at the time 1220, 26 August 1978. These are based on 24 hours of data beginning at this time.

aliasing may be present here due to the current reversal which dominated the flow during this 24-hour period. Figure 7 shows the tidal ellipses for the diurnal component (with a 24.61 hour period) in Region I (Fig. 1) based upon 72 hours of data. Clearly, the semi-diurnal tides appear to dominate the diurnal tides in the eastern strait.

We compared the general shape and magnitude of the tidal ellipses with those in a study of Parker (1977) who computed current-tidal components in the Strait of Juan de Fuca using current-meter data. His Figure 19 shows current ellipses for the M2 component which can be compared with our Figs. 6.03 and 6.04 in a few locations. In Fig. 6.03, for example, consider the tidal ellipse labeled "A". The direction of rotation is the same as Parker's ellipse, the length of the major axis is about the same (∿80 cm/s) and the direction of the major axis also appears to be the same. Other ellipse comparisons show similarly good agreement.

When we compare ellipse "B" in Fig. 6.04 with an ellipse in a comparable location in Parker's Fig. 19, we see a major axis of about 30 cm/s in the radar derived ellipse and 40 cm/s in Parker's ellipse with the direction of these axes about the same in both cases. In this example the radar data sample was only 24 hours long so one cannot expect quite as good agreement as in the previous case. During the time that these radar observations were made, the surface-current reversal occurred; this can be seen in both the radar and the current-meter data. The reversal introduced a bias in our calculations of the tidal coefficients for this time. A continuing analysis of these data sets is underway and a more detailed description of tidal circulation will be published when completed.

In addition, there are some interesting features in these ellipses as a function of location in the strait. For example, the direction of rotation of these ellipses changes from east to west. Starting with the easternmost ellipses (Fig. 6.03), the sense of rotation is in the counterclockwise direction. Then, as we scan westward, the sense reverses to the clockwise direction in many cases. This indicates a phase reversal in the north-south component which was also seen in the current meter data.

CURRENT METER COMPARISONS

Figure 8.00 shows the locations of three current-meter strings that were deployed by PMEL for the experiment. The radar-measured surface currents at these locations are compared with the current meters at a depth of 4 meters in Figs. 9.00 and 10.00. There is a strong correlation between the two data sets, especially in the east-west current component. Differences between these data may be due to the depth dependence of the near-surface currents and the different spatial sampling that is associated with each type of measurement. The radar-measured currents are averaged over a region of about ten square kilometers, while the Vector Averaging Current Meter (VACM) current measurements were obtained for "point" locations. These are different measurements which complement one another and provide a more complete picture of the flow.

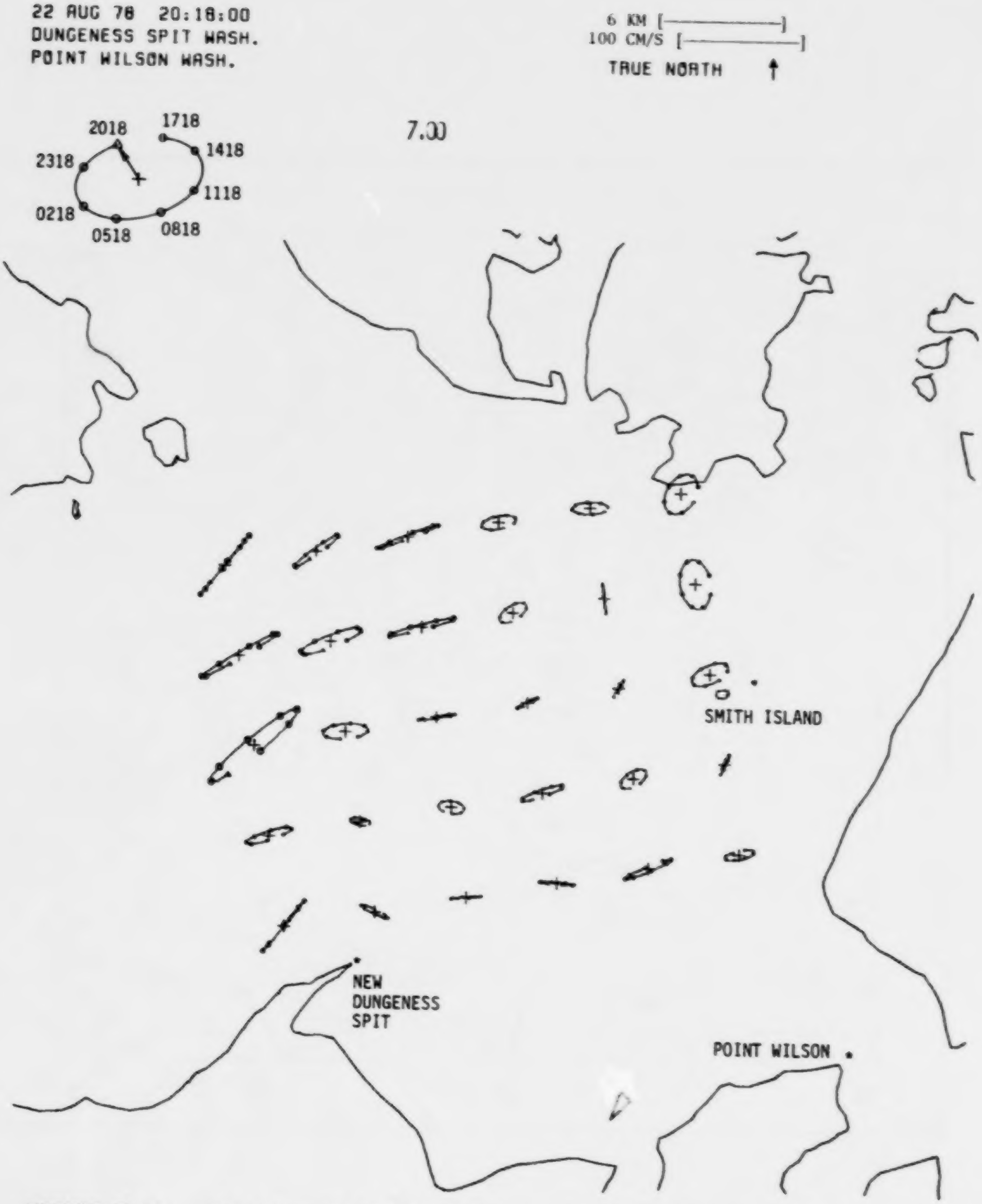
22 AUG 78 20:18:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.
6 KM
100 CM/S
TRUE NORTH
7.00
2018
1718
1418
2318
1118
0218
0518
0818
SMITH ISLAND
NEW DUNGENESS SPIT
POINT WILSON

FIGURE 7.00. The diurnal tidal ellipses are given for part of the Eastern Strait of Juan de Fuca. The triangle symbol marks the starting point for the ellipse at the time 2018, 22 August 1978. These are based upon 72 hours of data beginning at this time.

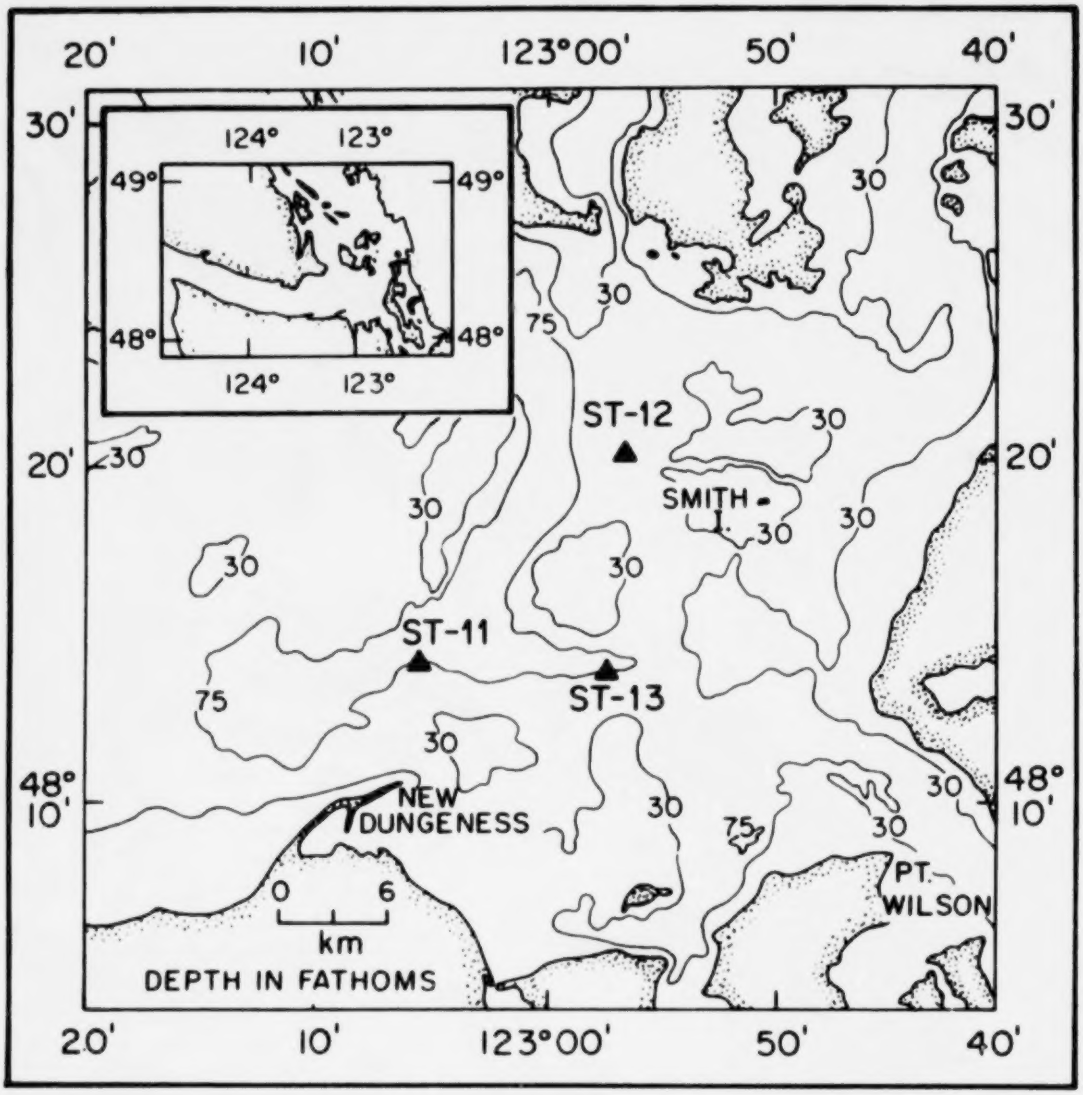
20'
10'
123°00'
50'
40'
30'
20'
48°
10'
124°
123°
49°
48°
ST-12
ST-11
ST-13
SMITH
I.
NEW DUNGENESS
PT. WILSON
30
75
0
6
km
DEPTH IN FATHOMS

FIGURE 8.00. Current meter locations.

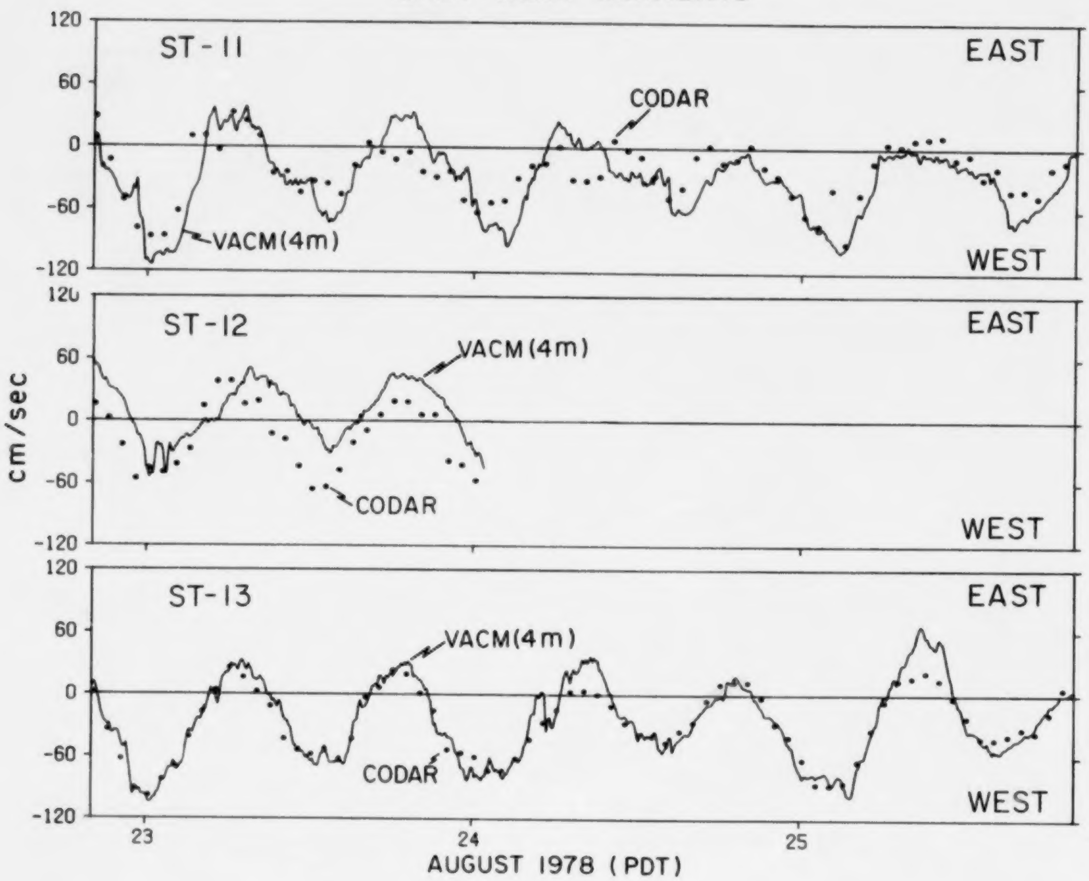

FIGURE 9.00. The radar measured current is compared with the current meter measurements at the four-meter depth for the east-west component.

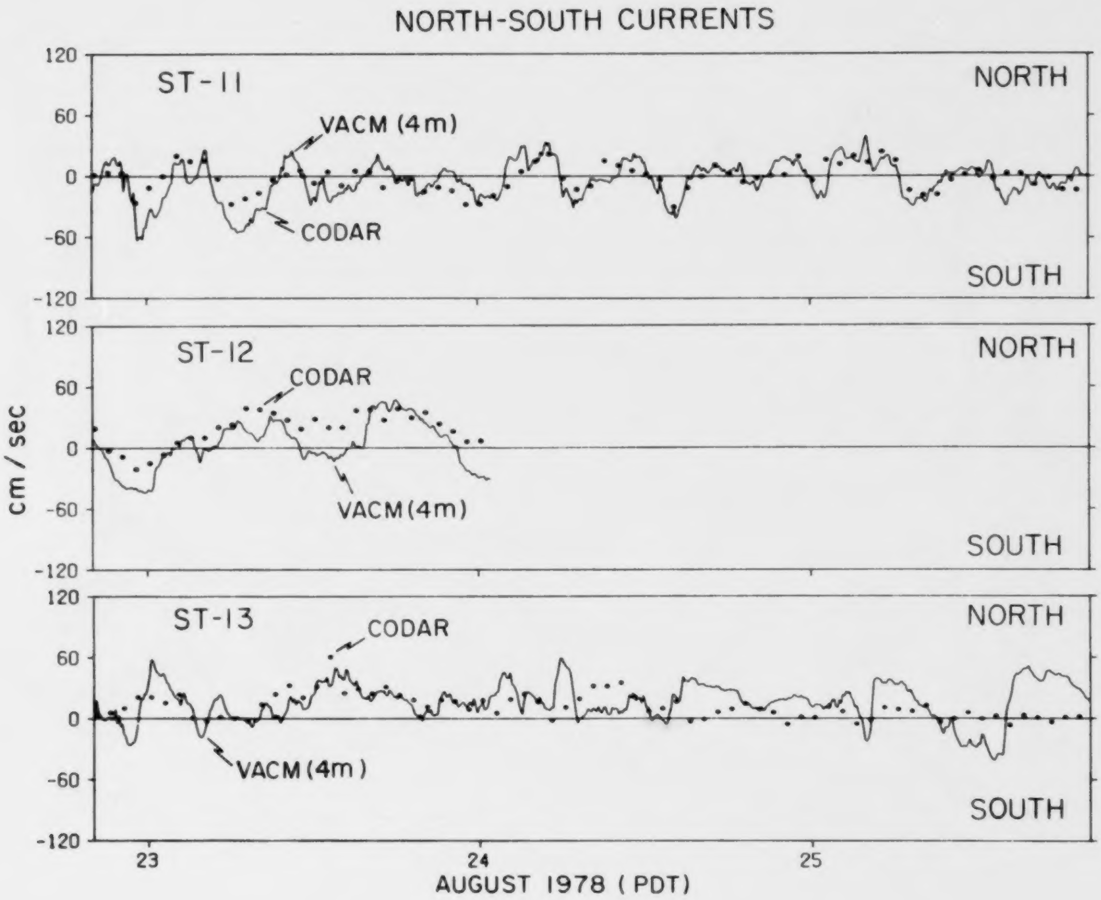

FIGURE 10.00. The radar measured currents are compared with the current meter measurements at the four-meter depth for the north-south component.

The tidal coefficients from the radar and current meters are compared in Table 1 for the two dominant tidal periods. The radar surface measurements lie within 10-15 m s^{-1} of the variation among the current meter measurements at 4, 10, 20 m depths. The mean current velocities measured by the radar and the current meters are compared in Table 2. For two of the current meters the differences were within 4 m s^{-1} of the variation in the measurements among the various depths. The disagreement at the third current meter location, however, appears significant and will require further analysis. Because time periods involved were brief, transient atmospheric conditions could have biased the near surface measurements.

DRIFTER COMPARISONS

During the course of the experiment, only a fraction of the drifters deployed and tracked by Evans-Hamilton, Inc. were within the areas covered by the NOAA radar, therefore, inter-comparisons of the radar and drifter data cannot be made in all cases. However, we compared trajectories with twenty-three drifters on 25 August 78. The radar-deduced trajectories are shown along with the measured locations of the drifters in Figs. 11.0 - 11.11 and in the Appendix (Figs. A3.00 - A3.45). Figure 11.00 shows the C0* drifter locations (marked with circles) and the radar inferred track (marked at half-hour intervals), where the radar track was computed from consecutive current maps. The differences in these two trajectories are probably attributable to the inherent differences in the two types of observations. The drifter trajectory is controlled by the instantaneous velocity at its immediate location, while the radar derived trajectory is a function of the entire velocity field averaged over several square kilometers. A horizontal current shear, which produces a velocity difference of 1 cm/s for two drifters very close together initially, will cause them to separate by almost a kilometer after 24 hours. We have identified current shears as large as 10 cm/s across a kilometer. Equally important is the difference in time resolution between the two kinds of measurements. The radar velocity measurements are made using sea-echo Doppler spectra derived from 10 - 30 minutes of data. Thus, the radar measurements also involve a time average of the currents, while the drifter responds to the instantaneous currents.

Figure 11.01 gives the radar predicted track for the C0 drifter, using only the tidal and mean currents. Differences in these two tracks will depend on the spatial and temporal resolution in the radar data and on the accuracy of the tidal coefficients. The radar data have a spatial resolution of about 2 km and a time resolution of about 36 minutes, since the latter is our averaging time for each current measurement. The accuracy of the tidal coefficients is limited by the number of spectral components that could be least-squares fitted to the data, and determines the completeness of the Lagrangian picture as predicted by the radar.

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* The drifters were each given an alpha-numeric designation which was printed on the drift sheet (Ebbesmeyer, 1978).

TABLE 1. The coefficients of the two main tidal components are compared for the radar and the current meters at all three depths. While the tidal currents are expected to be only weakly dependent upon depth, there is some variation even among the different current meter depths. The time is that used for computation of the tidal coefficients. The M2 component has a period of 12.3 hours and the K1 component has a 24.61-hour period.

LEAST SQUARES TIDAL AMPLITUDE COMPARISON

Location	Series	T (Hours)	East-West ($cm\ sec^{-1}$)		North-South ($cm\ sec^{-1}$)	
			K1	M2	K1	M2
ST-11	CODAR	72	15.3	28.9	3.4	4.2
	VACM/4M	72	14.2	42.3	3.0	2.6
	VACM/10M	72	15.2	47.1	4.5	10.7
	VACM/20M	72	16.2	50.6	6.7	5.4
ST-12	CODAR	29	13.0	39.7	9.6	14.4
	VACM/4M	29	9.1	30.3	11.6	21.6
	VACM/10M	29	9.0	31.1	11.0	18.8
	VACM/20M	29	12.4	41.8	11.1	29.4
ST-13	CODAR	72	16.8	43.7	3.7	2.8
	VACM/4M	72	20.9	50.3	6.2	14.8
	VACM/10M	72	19.7	48.8	4.8	14.8
	VACM/20M	72	18.6	46.8	1.0	12.5

TABLE 2. The mean current velocity is given at the surface (from radar data) and at three depths (from the current meter data).

TIME SERIES STATISTICS

Location	Series	T (Hours)	East-West Mean ($cm \cdot sec^{-1}$)	East-West Variance ($cm \cdot sec^{-2}$)	North-South Mean ($cm \cdot sec^{-1}$)	North-South Variance ($cm \cdot sec^{-2}$)
ST-11	CODAR	72	-23.6	748	-2.1	166
	VACM/4M	72	-30.3	1119	-4.4	310
	VACM/10M	72	-28.5	1376	-0.5	370
	VACM/20M	72	-24.1	1477	-3.6	241
ST-12	CODAR	29	-18.3	984	19.5	304
	VACM/4M	29	6.3	765	2.3	526
	VACM/10M	29	7.0	647	0.8	307
	VACM/20M	29	4.2	981	1.2	489
ST-13	CODAR	72	-28.6	1054	11.7	154
	VACM/4M	72	-25.8	1421	16.3	310
	VACM/10M	72	-23.9	1331	13.2	217
	VACM/20M	72	-16.9	1258	10.5	174

The trajectories in Figs. 11.02 and 11.03 illustrate how, in some cases, apparently high spatial resolution is obtained with the radar. The raw radar data was used to compute the track in Fig. 11.02 which little resembles that of drifter C3. This is probably due to the fact that, at the location of this drifter, the distance to the Point Wilson site is so large that the signal-to-noise ratio of the sea echo data is relatively poor. However, the mean velocity and tidal currents produced a very accurate estimate of the drift track in Fig. 11.03.

Another more convolved trajectory was duplicated in Fig. 11.04 over a time interval of about 10.5 hours. This and the other tracks shown here suggest that the radar has sufficient spatial and temporal resolution to track drifters (or oil slicks) in a complicated current field. Part of the differences seen here are probably caused by insufficient or faulty processing of the radar data. One of the reasons that experiments of this nature are important is that radar system development and understanding can be gained through application in real situations with known conditions.

Figures 11.05 and 11.06 provide another case in point. The drifter track in Fig. 11.05 was made by using just the tidal and mean currents. We can see the hypothetical drifter going north and to the east, diverging from the actual drifter track. However, when we add all of the data (Fig. 11.06), namely the instantaneous temporal fluctuations in the surface current, we obtain very good agreement with the drifter track. The computed drifter track does not go to the end of the regular drifter track because the data were being taken at the extreme range of one of the radars. Analogous behavior is seen in Figs. 11.07 and 11.08 for drifter Y2. Disregarding the poor coastline registration, the raw radar data has the track going north along the coast while the mean and tidal currents cause the drifter to swing to the east and arc southward.

We include the drift comparisons which were not totally favorable to the radar. As an example, Fig. 11.09 shows a case where drifter Y4 was initially positioned too close to the baseline between the two radar sites. This is a particularly unstable region for the radar because both radar sites "see" the same radial current component. The other component of the total current vector is then indeterminant and produced the ragged track seen in Fig. 11.09. The track in Fig. 11.10 which used the mean flow and tides were no longer noisy, but transient surface currents may have been missed, possibly explaining the discrepancies with the actual drift track.

Finally, Fig. 11.11 reveals a "dogleg" in the drift track that was captured by both the radar and the drifter Y8. This illustrates the complexity of the circulation patterns that have length scales of a few kilometers. Although the radar can capture such detail, care must be exercised when comparing with surface drifters. The radar averages over an area which, in this case, caused the track to be displaced westward of the true drifter location. The radar reveals the trajectory geometry but it cannot precisely locate the drifter. This is a radar resolution effect.

FIGURES 11.00 thru 11.11. The positions of surface drifters deployed and tracked by Evans-Hamilton on 25 August 1978 are compared with Lagrangian trajectories derived from radar data. The label in the upper lefthand corner gives the data and time of the start of the drifter and computed trajectories, the date and time of the end of the computed trajectory, the RAW/ or TID/ denotes whether the radar derived radar track was raw radar data or tidally derived drift tracks which have the mean flow as well as tidal data respectively. The information to the right of the / denotes the Evans-Hamilton, Inc., drifter number (for example: in Figure A3.00 RAW/CO denotes the raw data with drifter number CO). The last number on the left shows the time of the end of the drifter track. The label in the upper righthand corner gives the spatial scale in km/in, the time between the tick marks of the radar derived trajectory and the direction of north. The Evans-Hamiltin, Inc. trajectory is denoted by circles, each circle represents the location position measurement was made on the drifter. The line with the tick marks denotes the radar-derived trajectory.

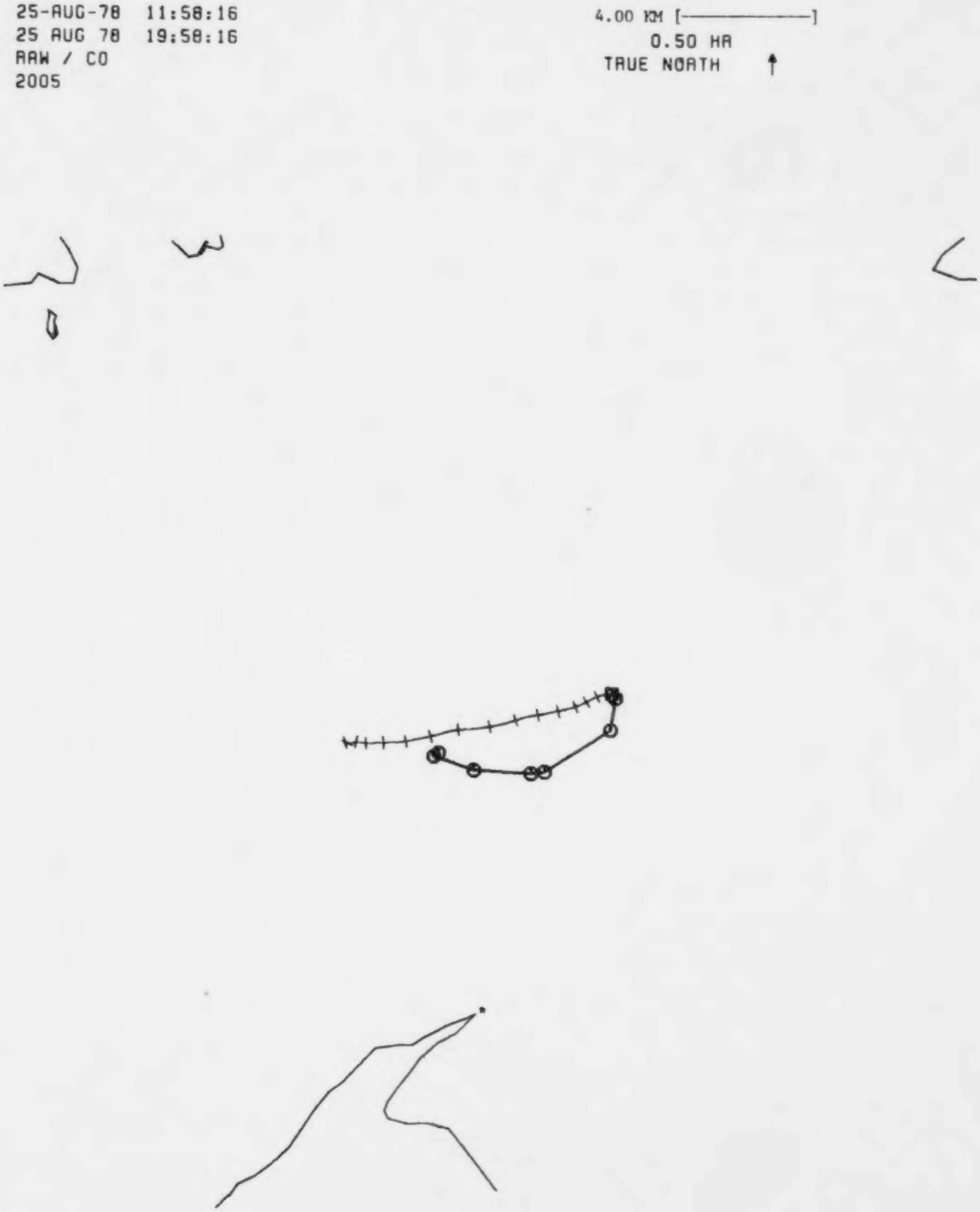

25-AUG-78 11:58:16
25 AUG 78 19:58:16
RAW / CO
2005
4.00 KM
0.50 HR
TRUE NORTH

FIGURE 11.00

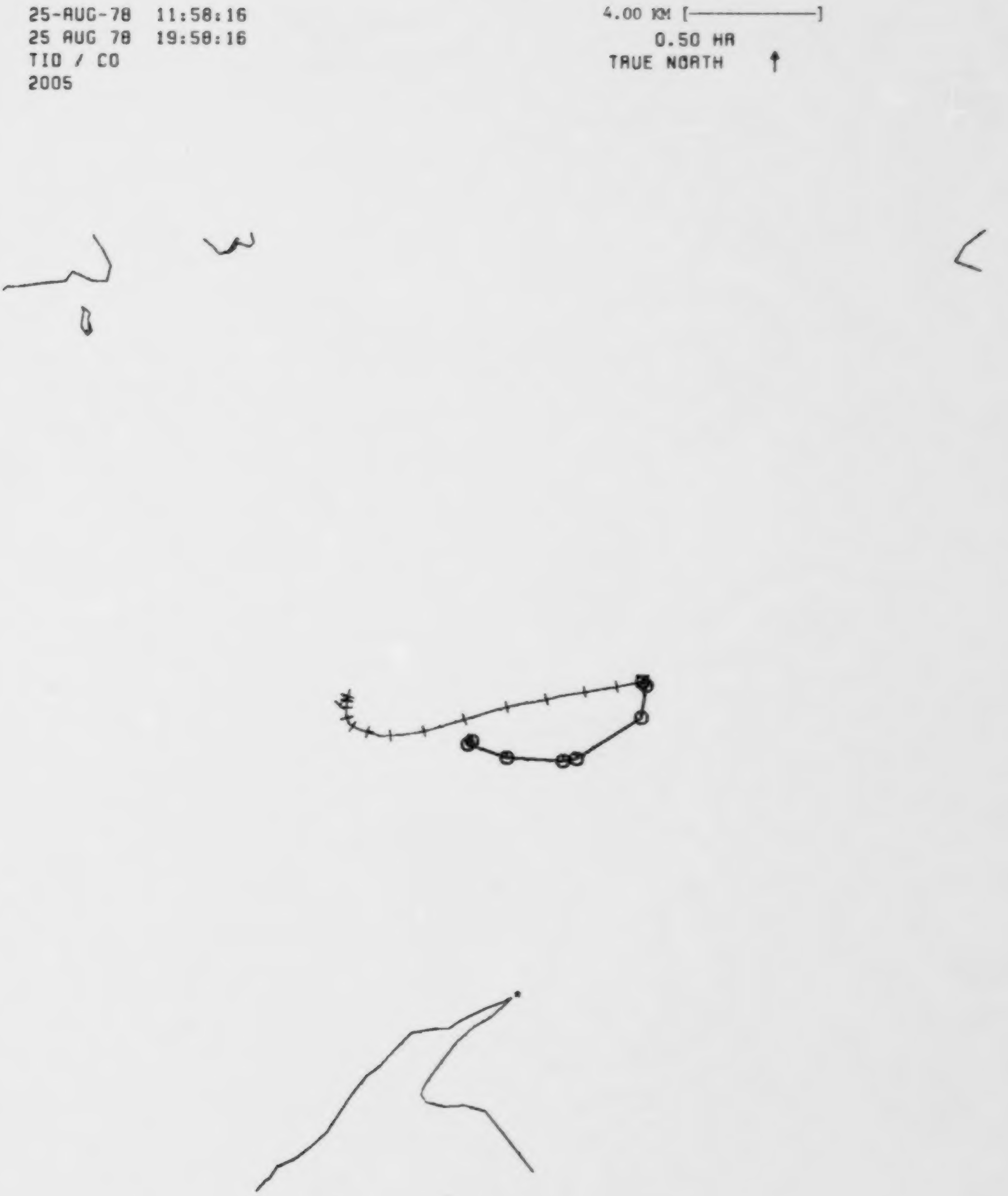

25-AUG-78 11:58:16
25 AUG 78 19:58:16
TID / CO
2005
4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

FIGURE 11.01

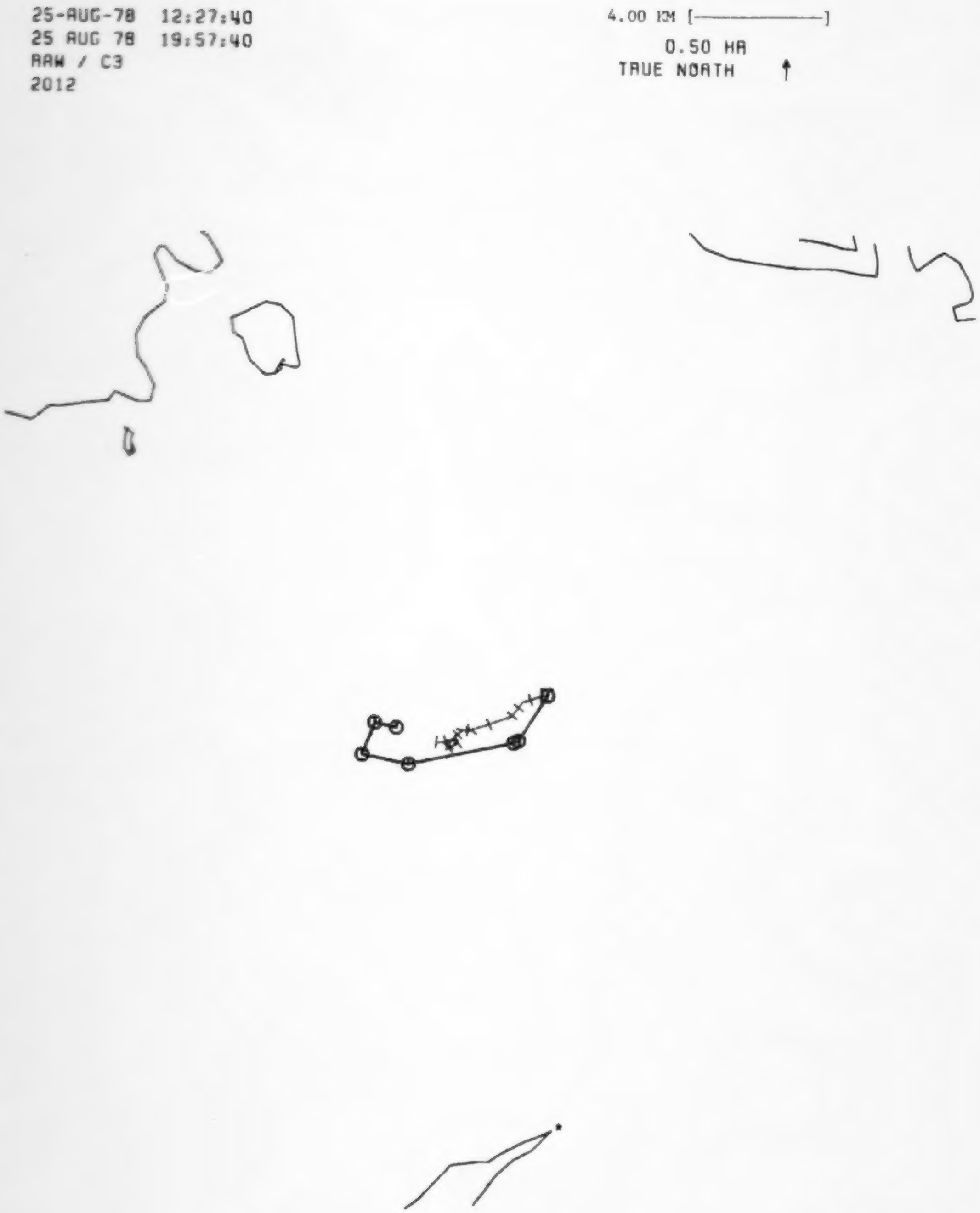

25-AUG-78 12:27:40
25 AUG 78 19:57:40
RAW / C3
2012
4.00 KM [-------------]
0.50 HR
TRUE NORTH ↑

FIGURE 11.02

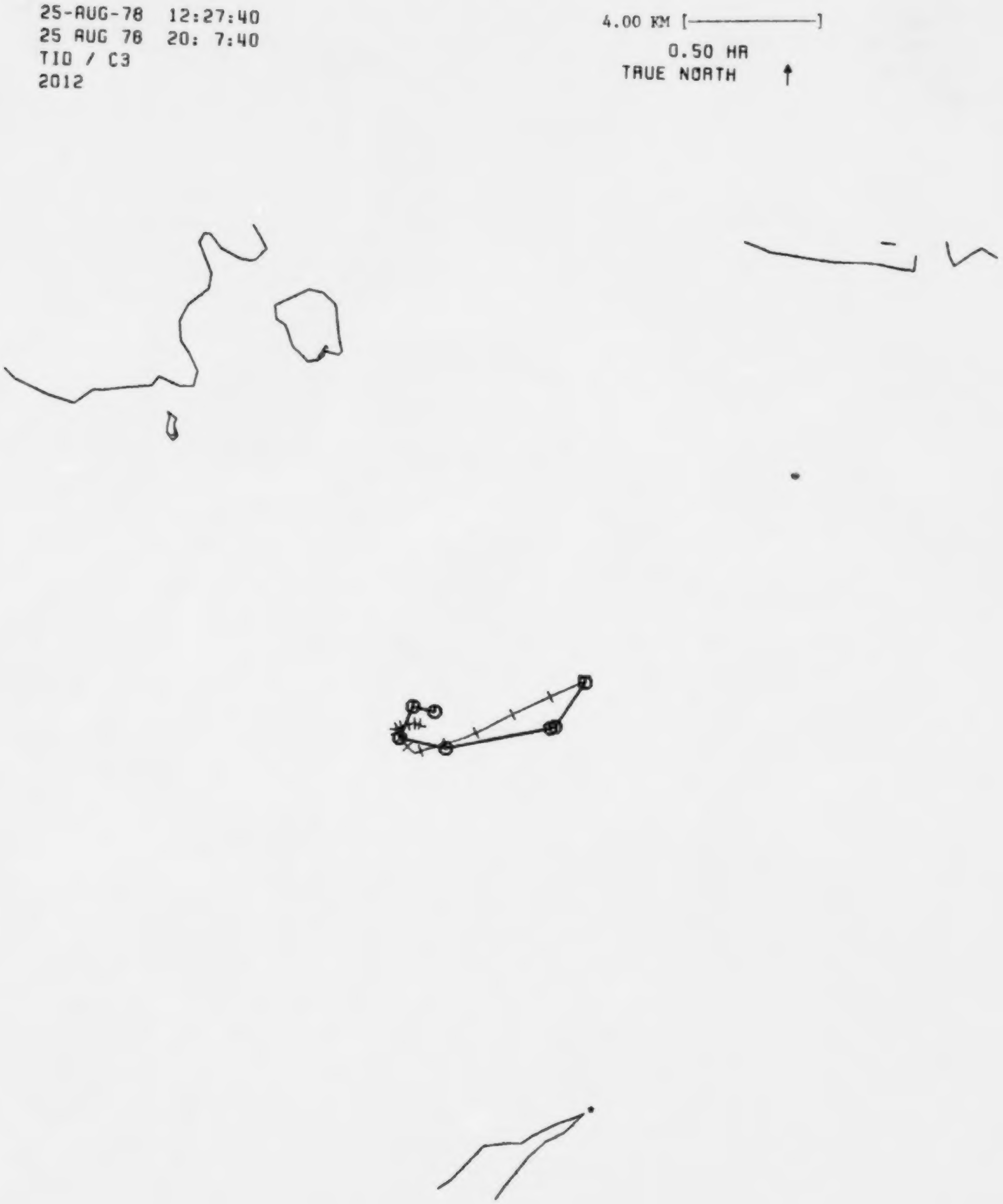
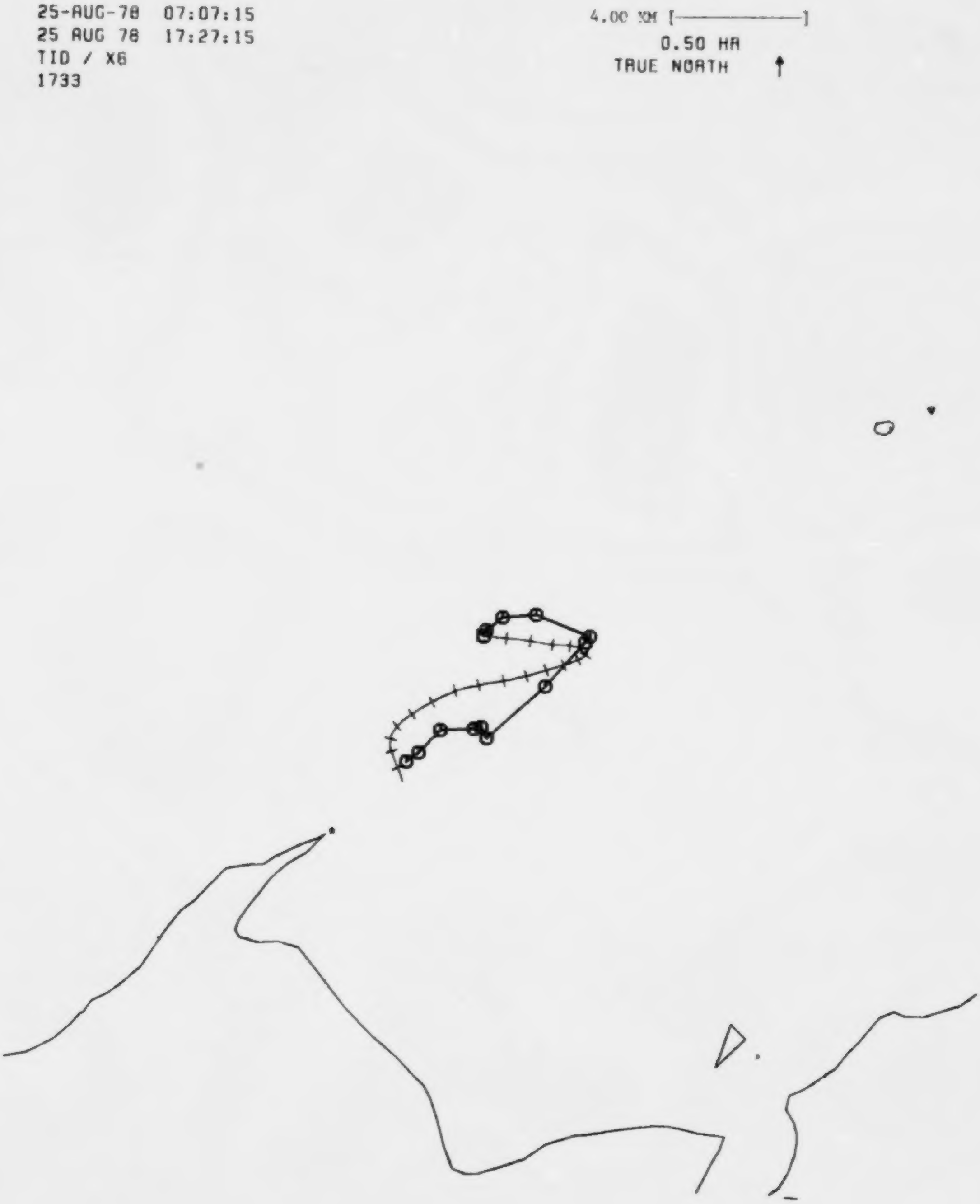

25-AUG-78 12:27:40
25 AUG 78 20: 7:40
TID / C3
2012
4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

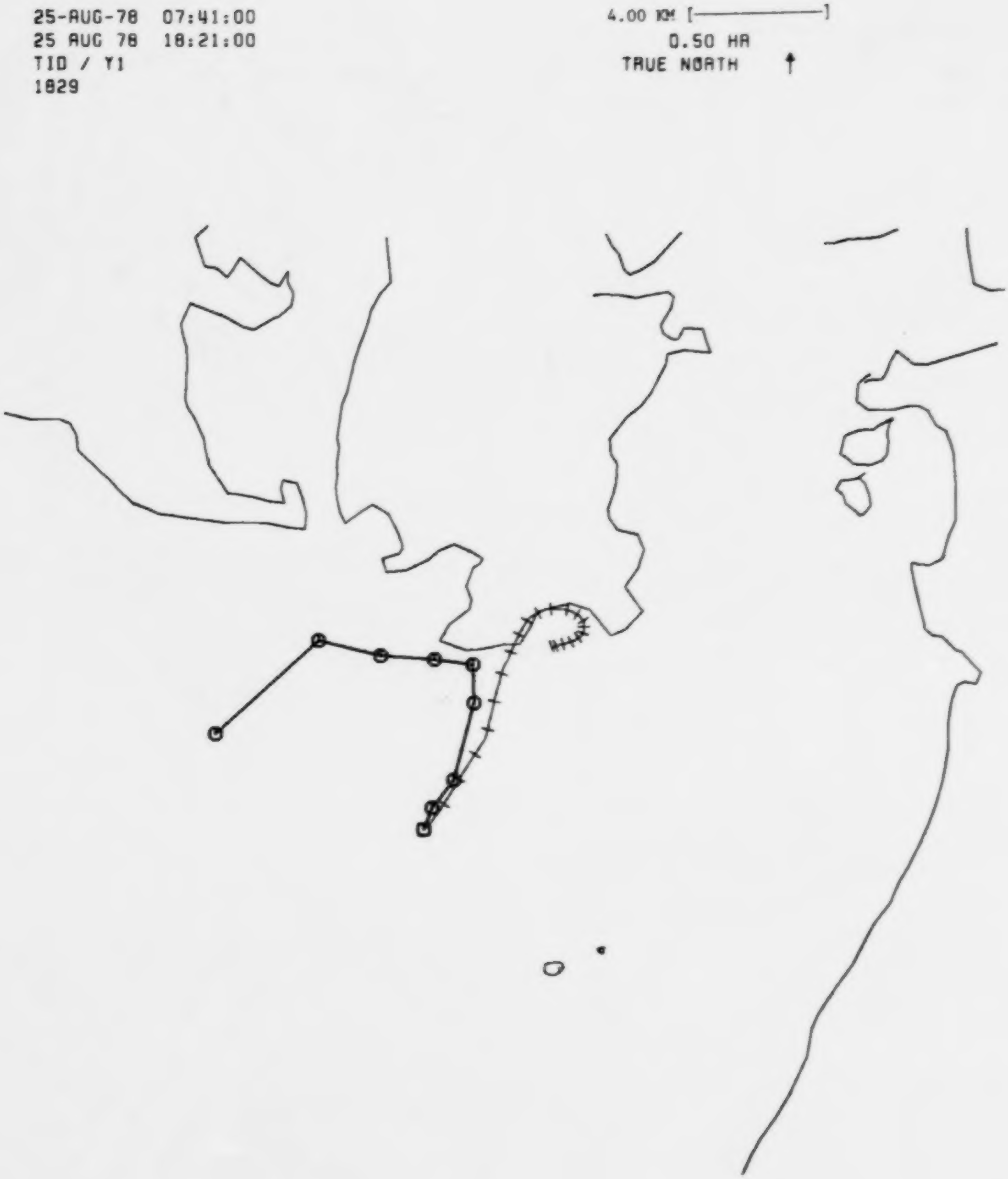
FIGURE 11.03



25-AUG-78 07:07:15
25 AUG 78 17:27:15
TID / X6
1733

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

FIGURE 11.04



25-AUG-78 07:41:00
25 AUG 78 18:21:00
TID / Y1
1829

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

FIGURE 11.05

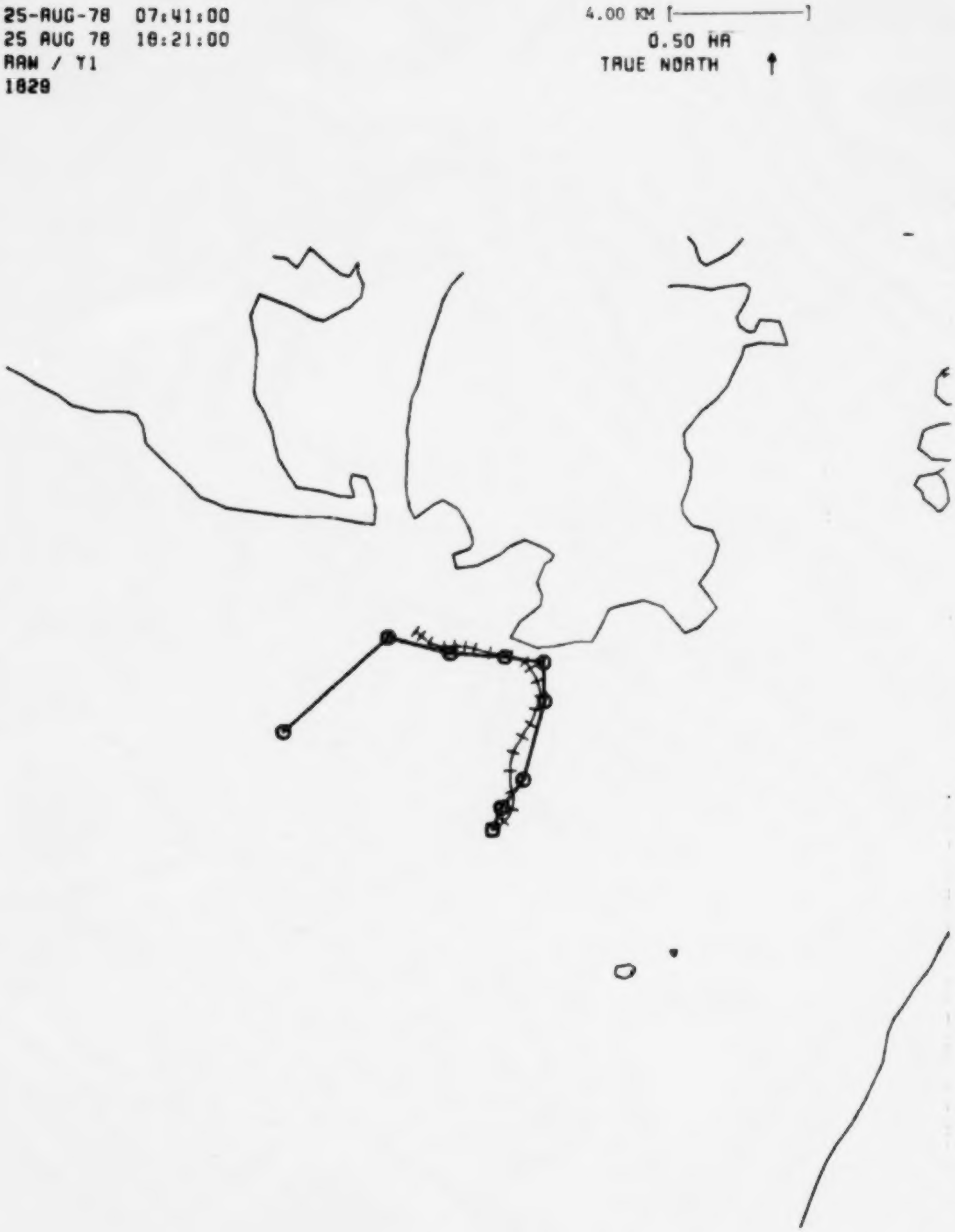

25-AUG-78 07:41:00
25 AUG 78 18:21:00
RAW / T1
1828
4.00 KM
0.50 HR
TRUE NORTH

FIGURE 11.06

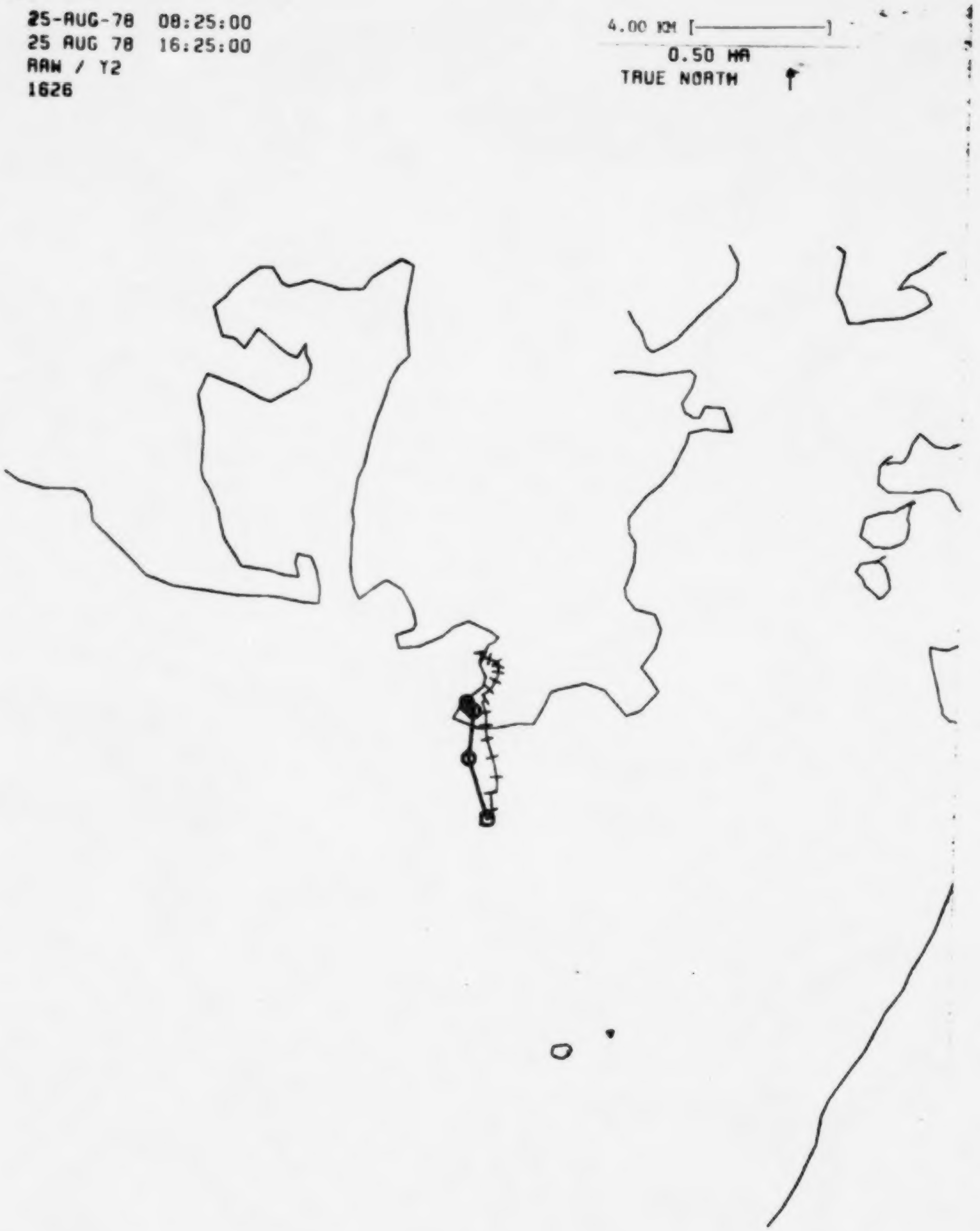

25-AUG-78 08:25:00
25 AUG 78 16:25:00
RAW / Y2
1626
4.00 KM
0.50 HR
TRUE NORTH

FIGURE 11.07

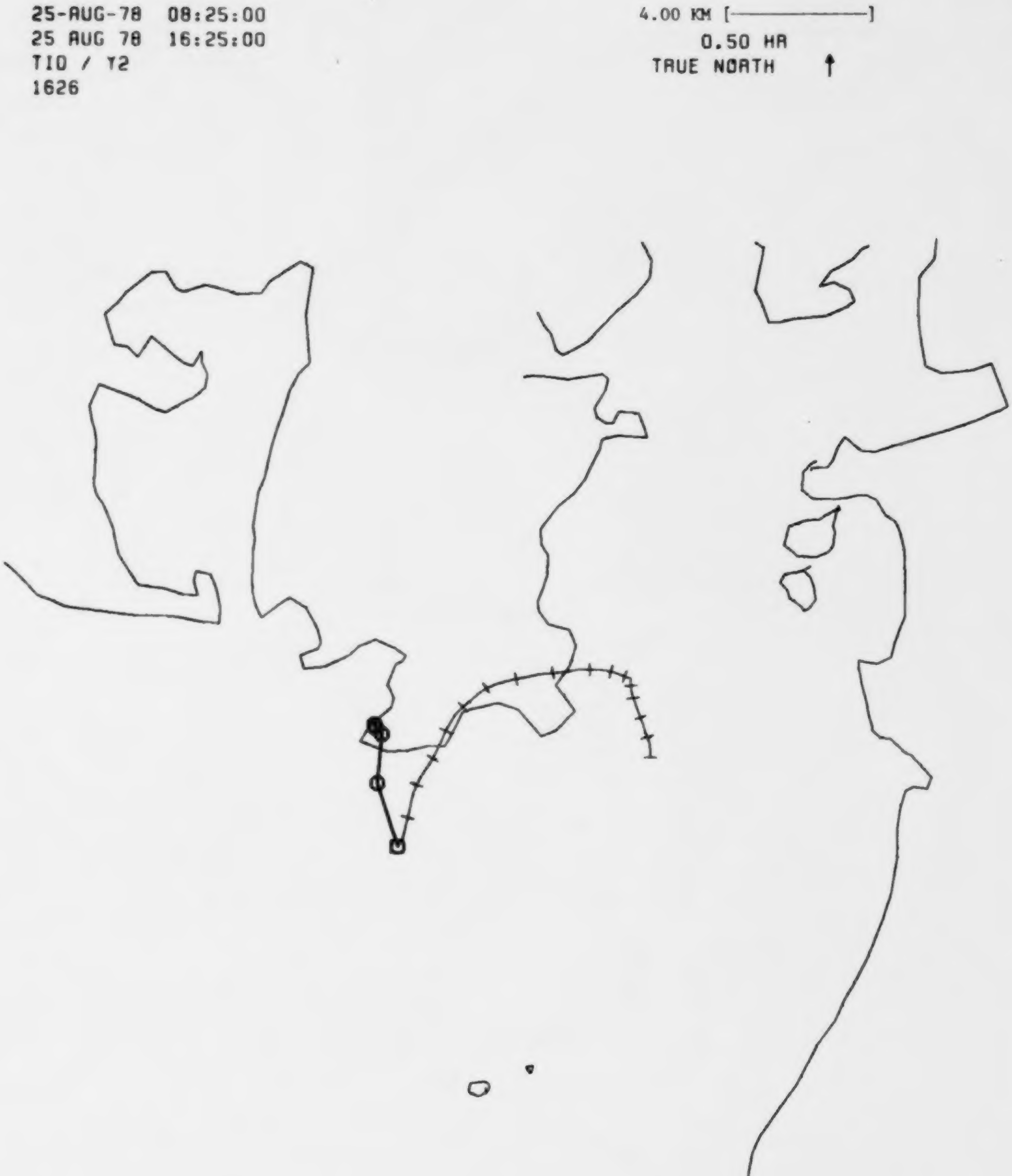

25-AUG-78 08:25:00
25 AUG 78 16:25:00
TID / Y2
1626
4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

FIGURE 11.08

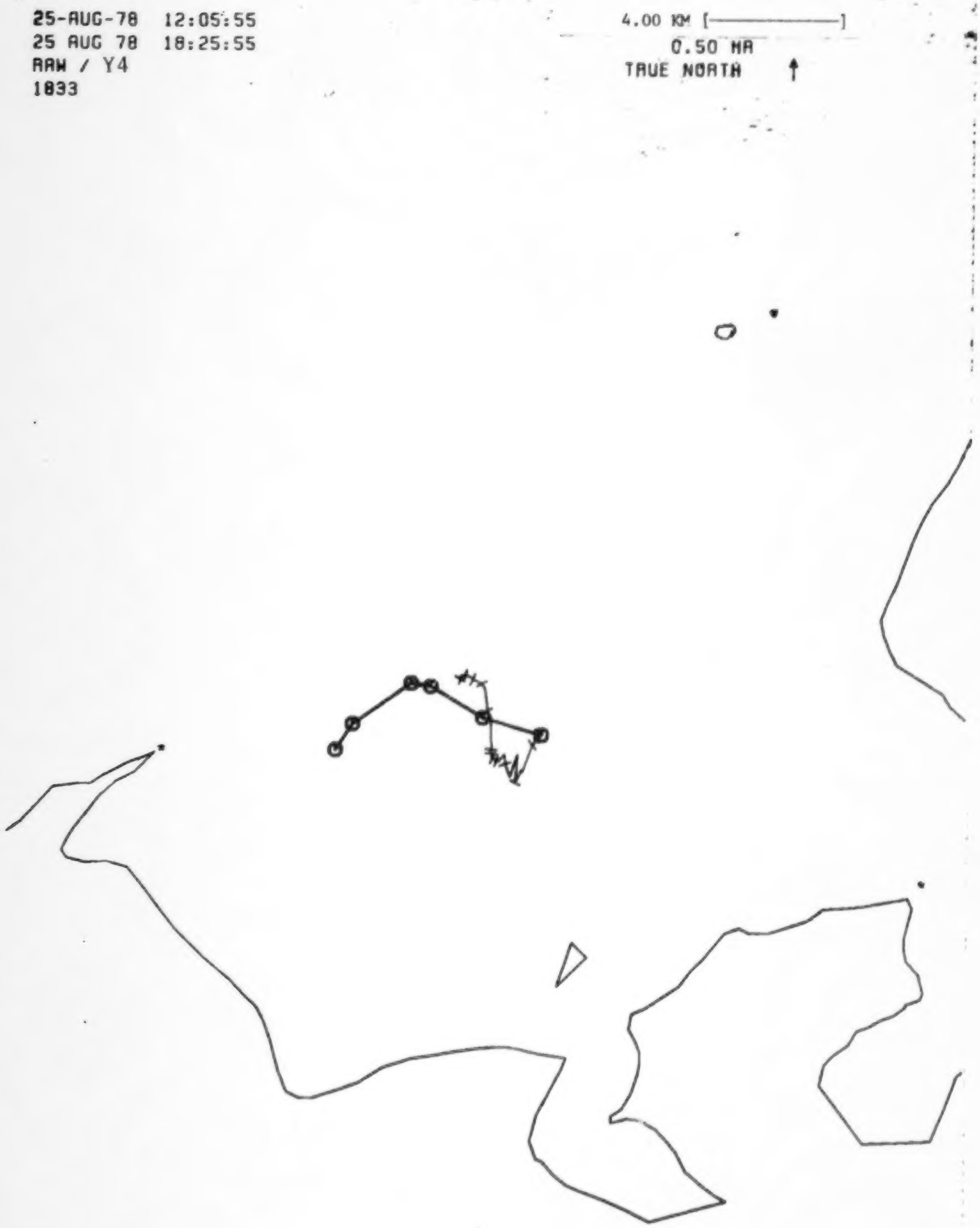

25-AUG-78 12:05:55
25 AUG 78 18:25:55
RAW / Y4
1833
4.00 KM [——————]
0.50 MR
TRUE NORTH ↑

FIGURE 11.09

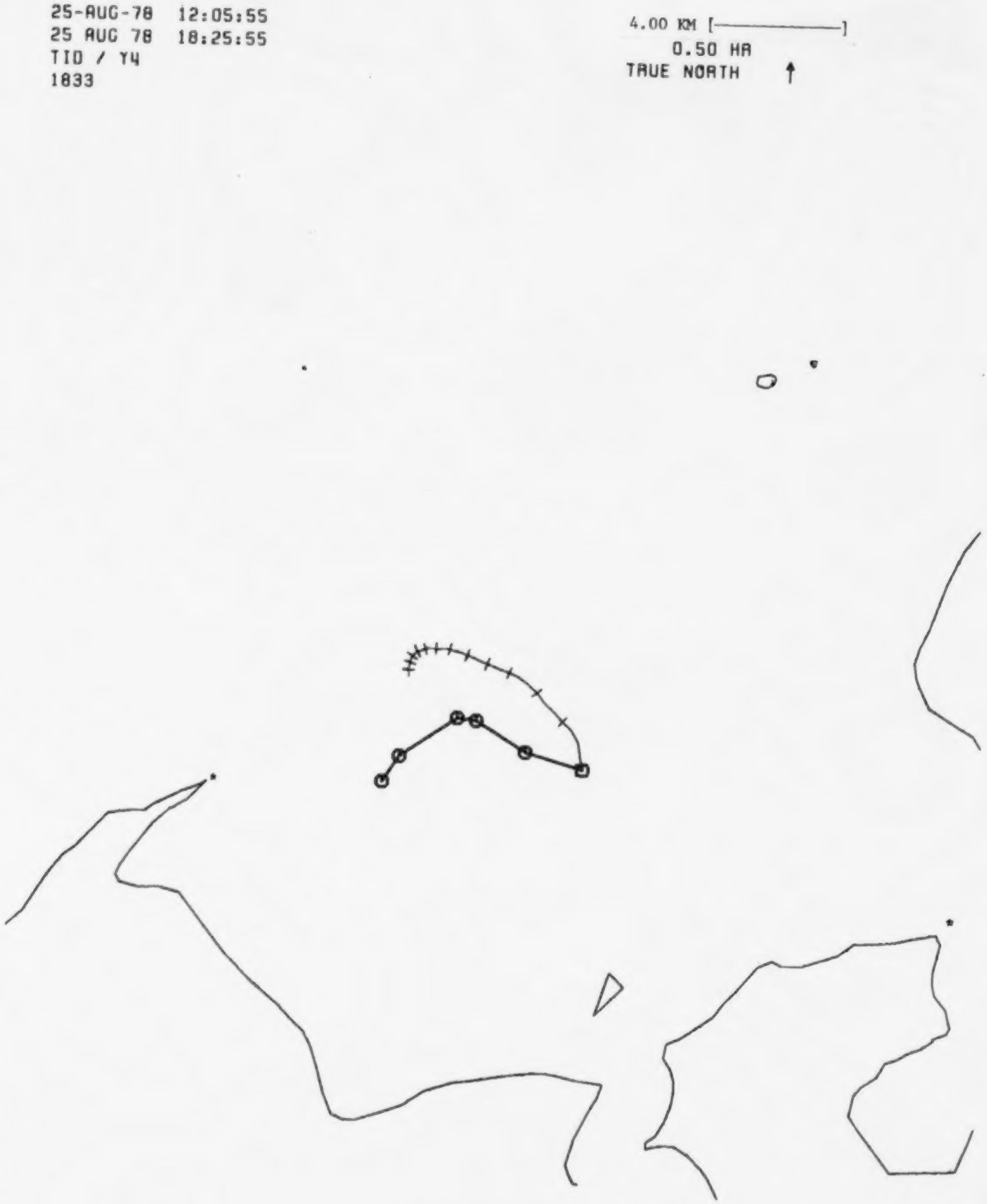

25-AUG-78 12:05:55
25 AUG 78 18:25:55
TID / Y4
1833
4.00 KM [ ]
0.50 HR
TRUE NORTH ↑

FIGURE 11.10

25-AUG-78 13:24:00
25 AUG 78 19:44:00
RAW / Y8
1953
4.00 KM
0.50 HR
TRUE NORTH

FIGURE 11.11

SPECIAL AREA

Although the entire region is of great interest and importance, Admiralty Inlet attracts special attention because it is the major entrance to Puget Sound. Detailed surface current maps for Admiralty Inlet are given in the Appendix (Figs. A4.00 - A4.71) for each hour between 2100 on 22 August and 2000 on 25 August. These maps are bordered by Whidbey Island to the east, the Quimper Peninsula to the south, and Protection Island to the southwest. A sample is shown in Fig. 12.00 which displays some of the strongest currents (to nearly four knots) noted by this study. In this case, the currents are almost entirely tidally driven.

The mean flow that was derived from 72 hours of data beginning on the evening of 22 August 1978 is shown in Fig. 13.00. While the net flow was apparently out of Admiralty Inlet, a feature in the center of the inlet indicates that upwelling may have occurred; this could be due to a bathymetry effect. The maximum mean velocity was about 25 cm/s, well below the mean flow farther out in the strait. Additionally, the tidal ellipses for the 12.3-hour tidal component (Fig. 14.00) and the 24.61-hour component (Fig. 15.00) clearly show the tides forcing water in and out of the inlet. Again the 12.3-hour component dominates.

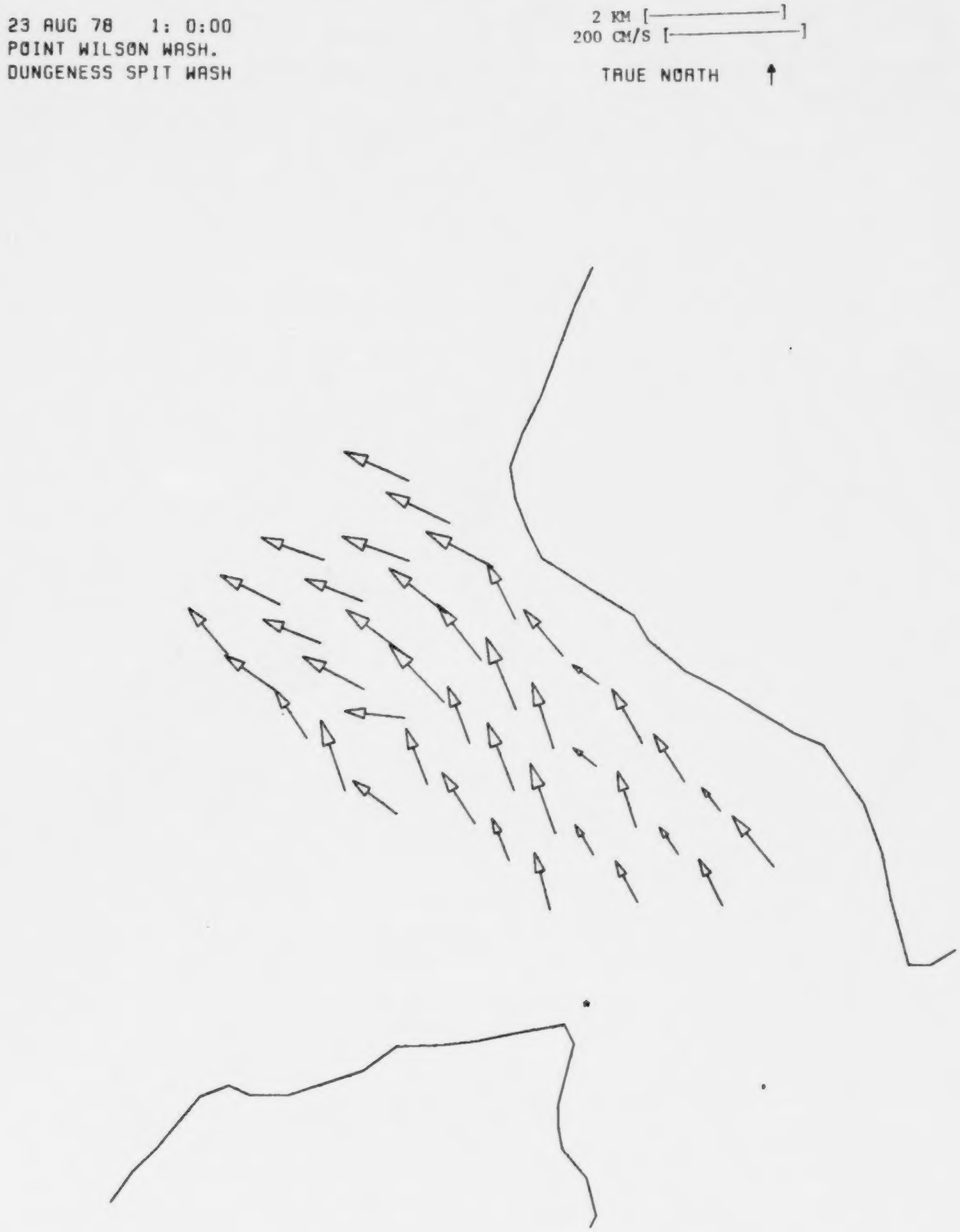

23 AUG 78 1: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH
2 KM
200 CM/S
TRUE NORTH

FIGURE 12.00. Some of the strongest currents just north of Admiralty Inlet which occurred during the 3-day measurement period.

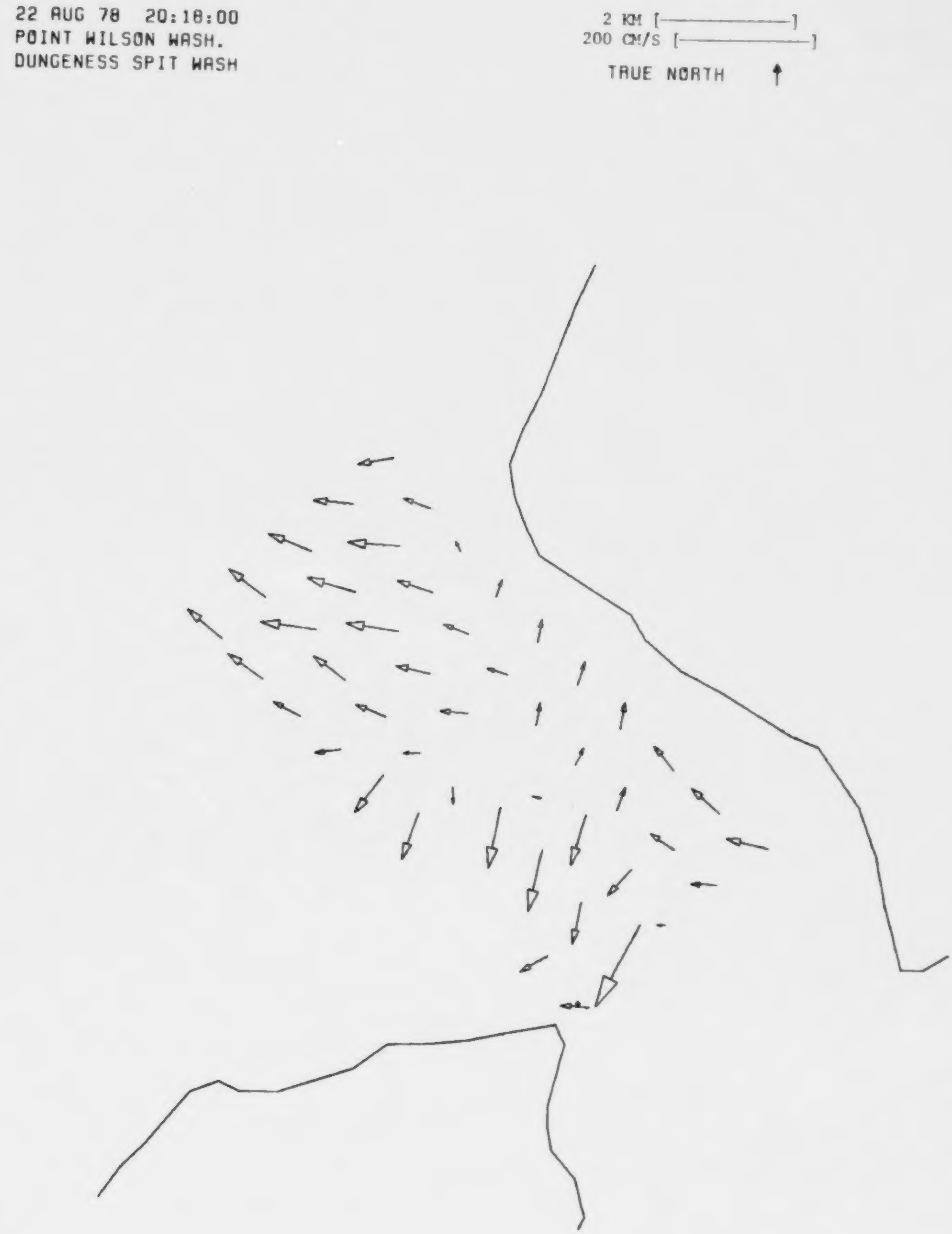

22 AUG 78 20:18:00
POINT WILSON WASH.
DUNGENESS SPIT WASH
2 KM
200 CM/S
TRUE NORTH

FIGURE 13.00. The mean flow at the north end of Admiralty Inlet based upon a 72-hour least squares fit.

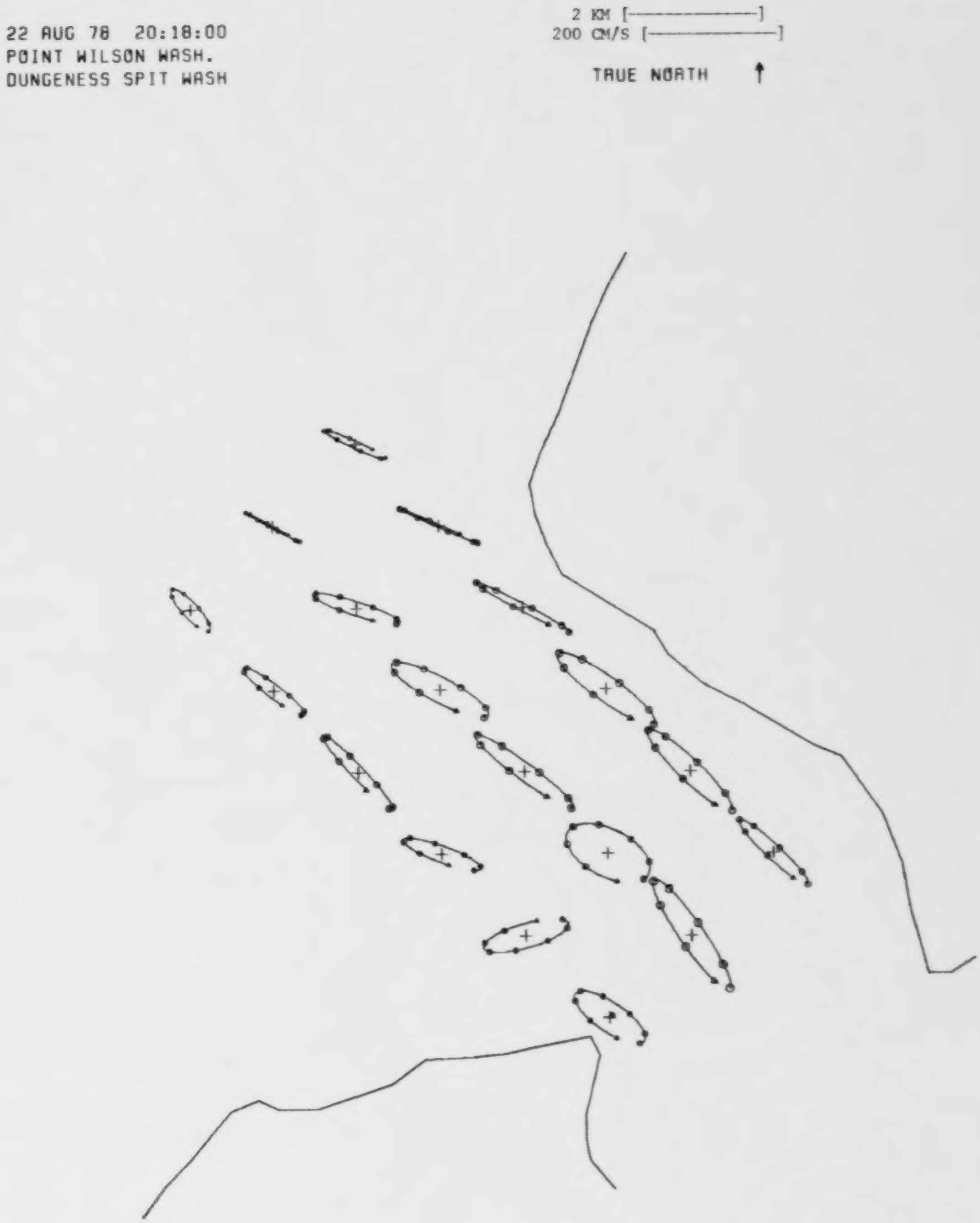

22 AUG 78 20:18:00
POINT WILSON WASH.
DUNGENESS SPIT WASH
2 KM [————————]
200 CM/S [————————]
TRUE NORTH ↑

FIGURE 14.00. The 12.3-hour tidal ellipses for Admiralty Inlet based upon 72 hours of data beginning on 2000, 22 August 1978.

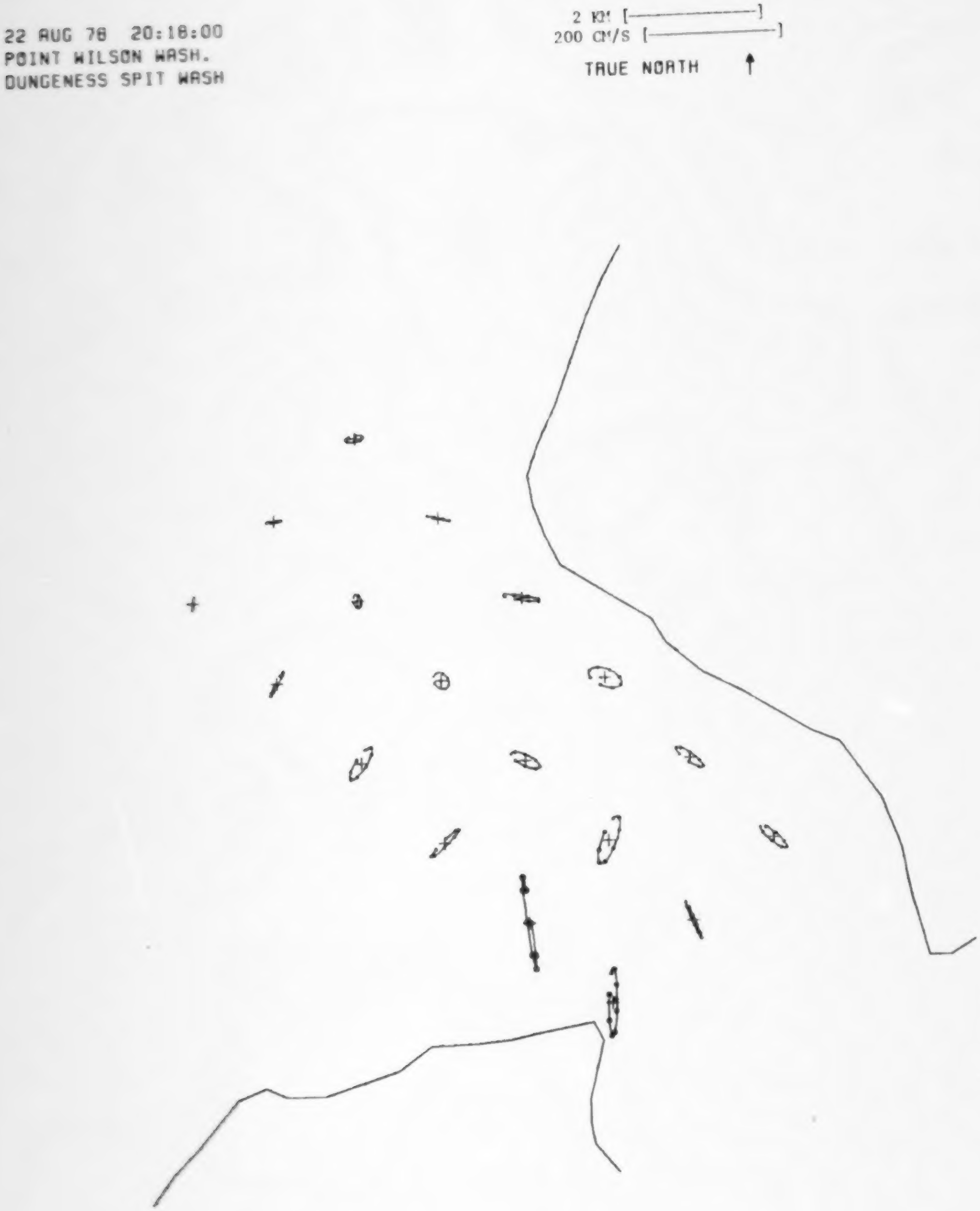

22 AUG 78 20:18:00
POINT WILSON WASH.
DUNGENESS SPIT WASH
2 KM
200 CM/S
TRUE NORTH

FIGURE 15.00. The 24.61 hour tidal ellipses for Admiralty Inlet based upon 72 hours of data beginning on 2000, 22 August 1978.

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APPENDIX

The first set of figures A1.00 to A1.71 are surface current maps for the eastern part of the Eastern Strait of Juan de Fuca. They represent the currents starting at 2100 on 22 August 1978. They are given for each hour and end on 25 August 1978 at 2000. The label in the upper lefthand corner denotes the date, time, and the two radar locations. The label in the upper righthand corner denotes the distance scale in kilometers, the current velocity scale in cm/s and the direction of true north. The second set of figures, A2.00 to A2.26, are surface current maps for one hour intervals for data taken in the western part of the Eastern Strait of Juan de Fuca between 1300 on 26 August 1978 and 1500 on 27 August 1978. The labels give the same information as in the first set of figures.

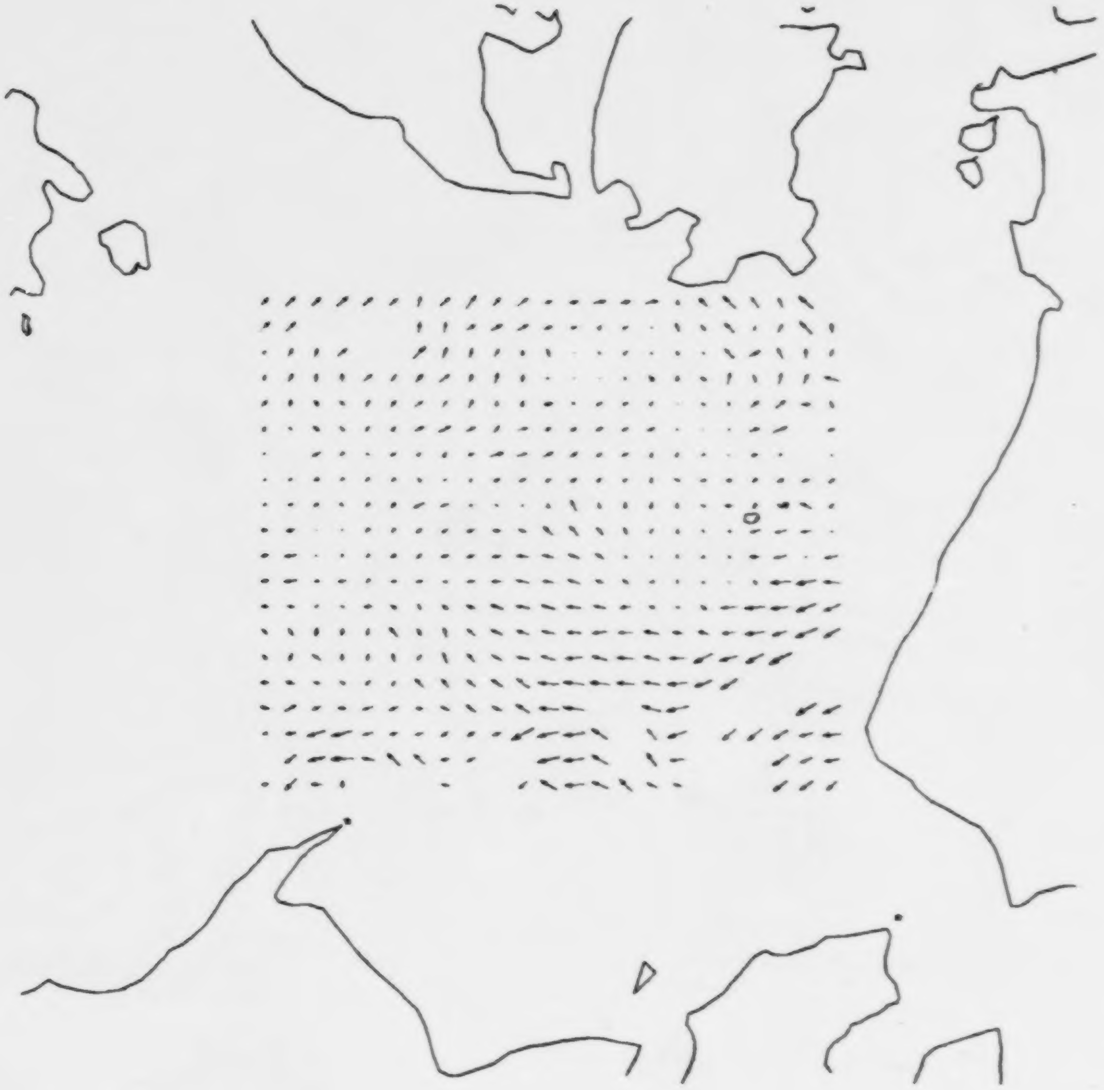
The third set of figures, A3.00 to A3.45, show the comparisons between the Evans-Hamilton, Inc. drifters and a predicted drifter track based on the radar data. The label in the upper lefthand corner gives the date and time of the start of the drifter and computed trajectories, the date and time of the end of the computed trajectory, and denotes whether the predicted track was derived from raw data or based only upon the tides and mean flow. The Evans-Hamilton, Inc. drifter number is also given. For example, in Fig. A3.00, RAW/CO indicates that raw data were used with drifter number CO. The last number on the left shows the end time of the actual drifter track. The label in the upper righthand corner gives the spatial scale in kilometers, the time between the tick marks of the radar derived trajectory in hours, and the direction of true north. The Evans-Hamilton, Inc. trajectory is denoted by circles, where each circle represents the location of a position measurement that was made on the drifter. The line with the tick marks denotes the radar-derived trajectory.

The last set of figures, A4.00 to A4.71, denote surface current maps near Admiralty Inlet, the area of special interest. These represent hourly data starting at 2100 on 22 August 1978 and ending on 25 August at 2000. The label gives the same information as in the first two sets of figures in this Appendix.

22-AUG-78 21:00:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

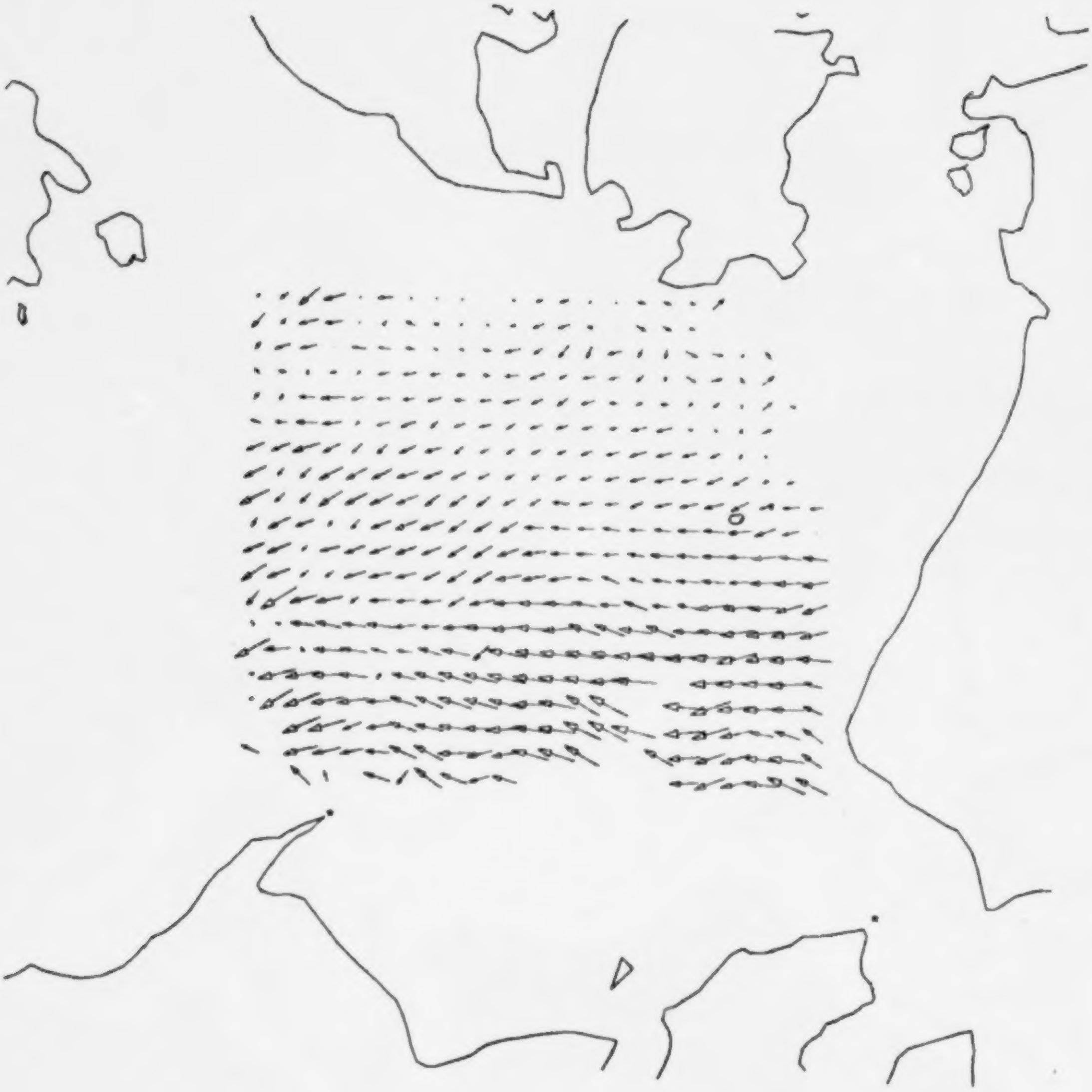
A 1.00



22 AUG 78 22: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

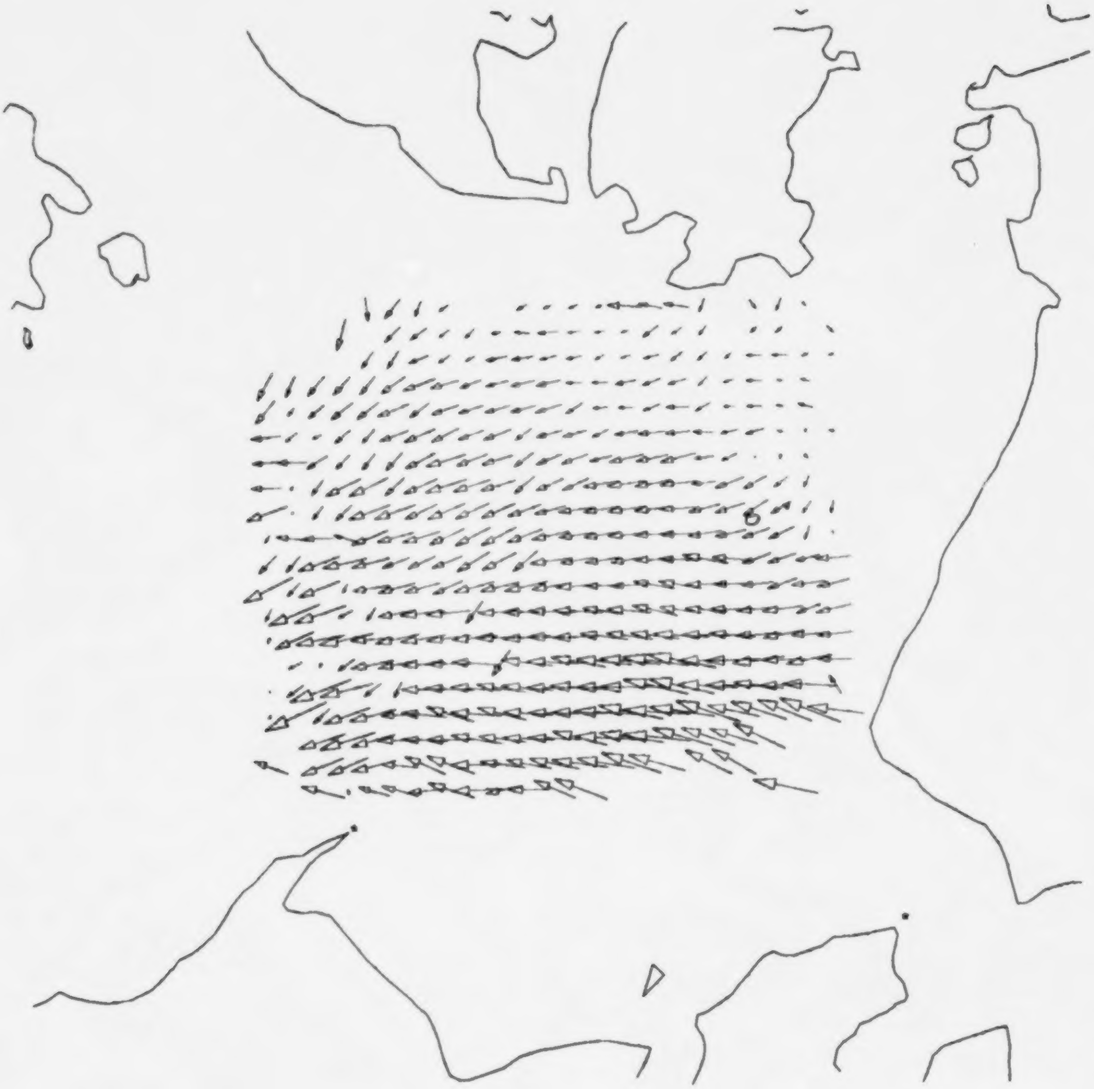
6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.01



22 AUG 78 23: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

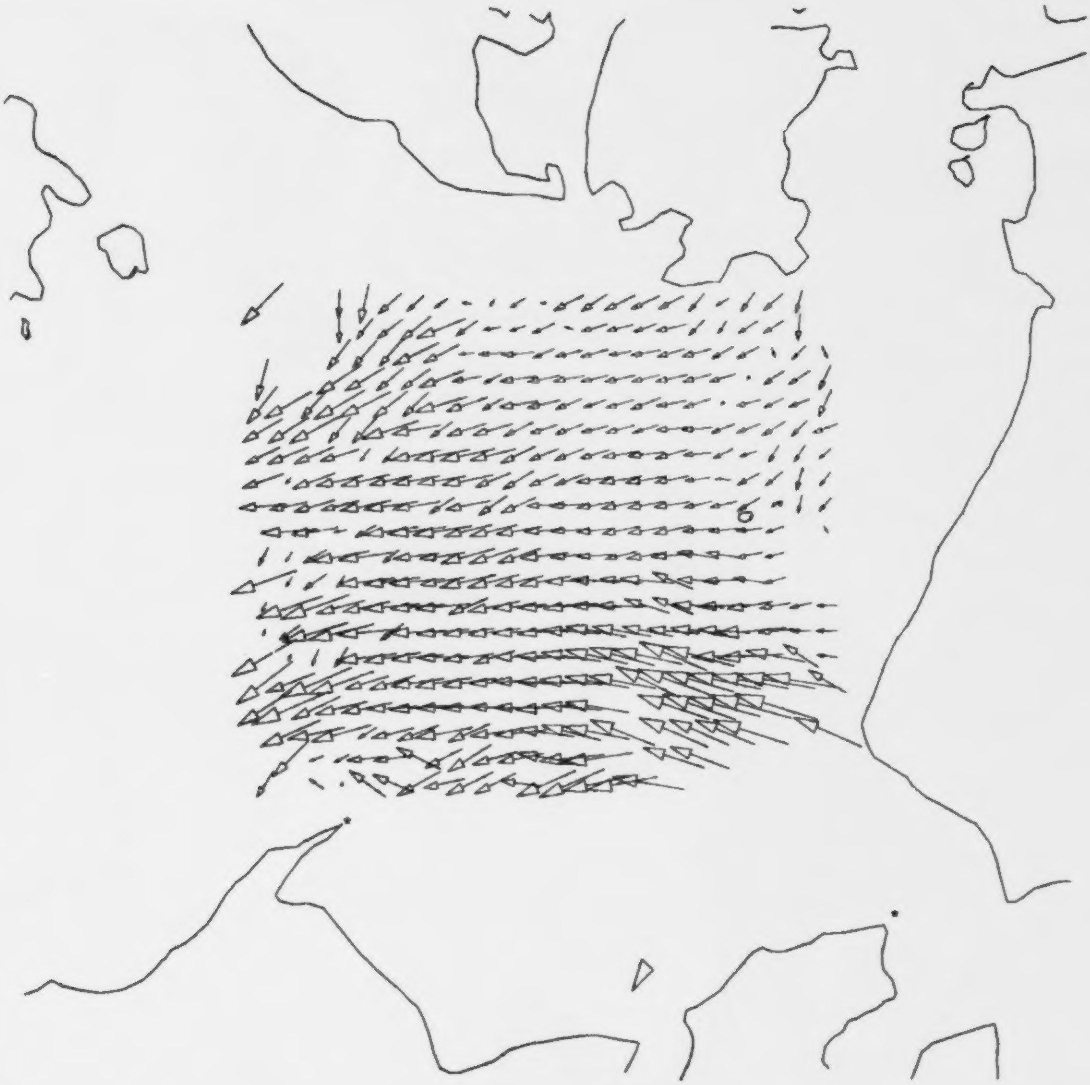
A 1.02


6 KM [——————]
200 CM/S [——————]
TRUE NORTH

23 AUG 78   0: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

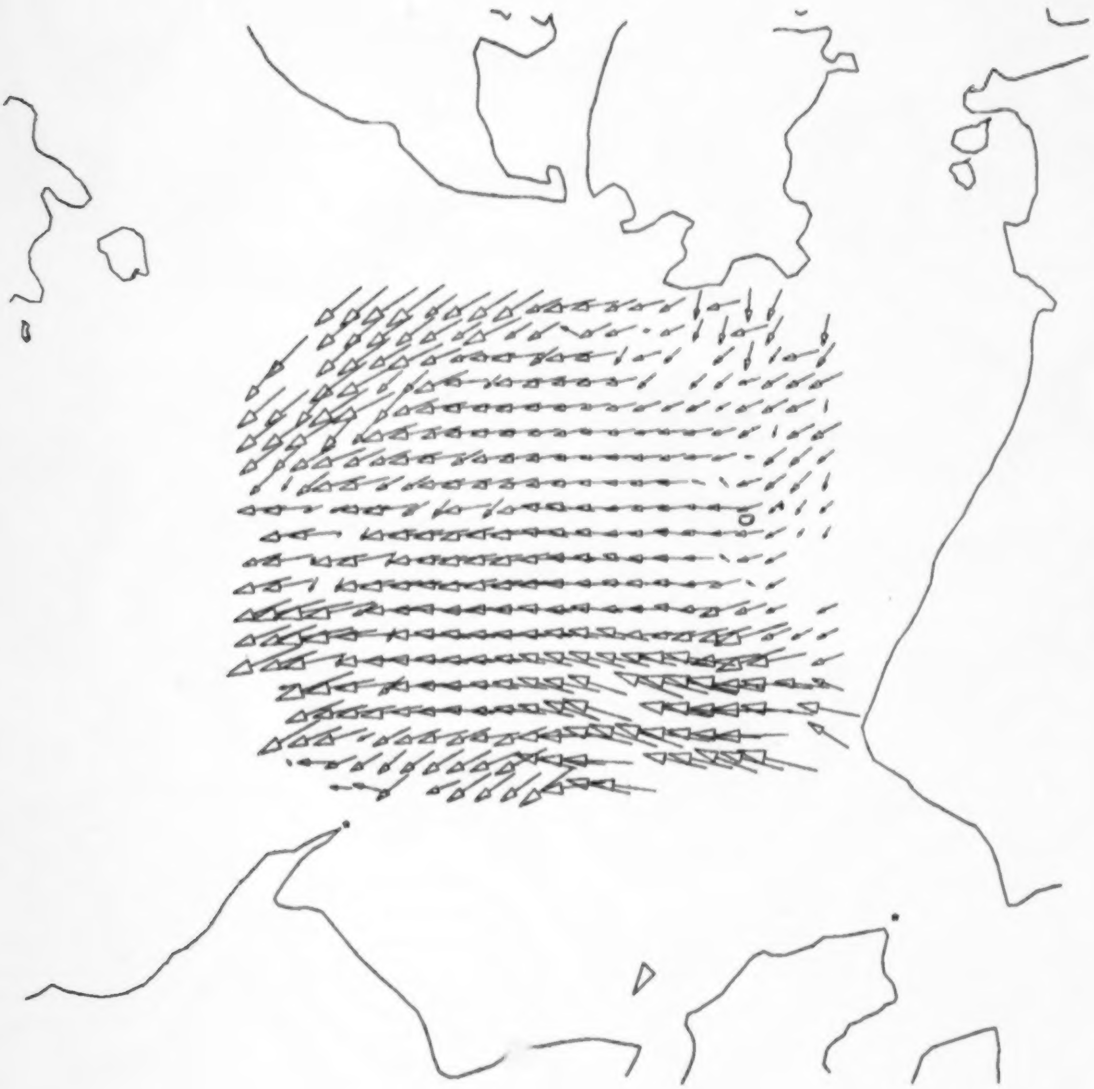
6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.03



23 AUG 78 1: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

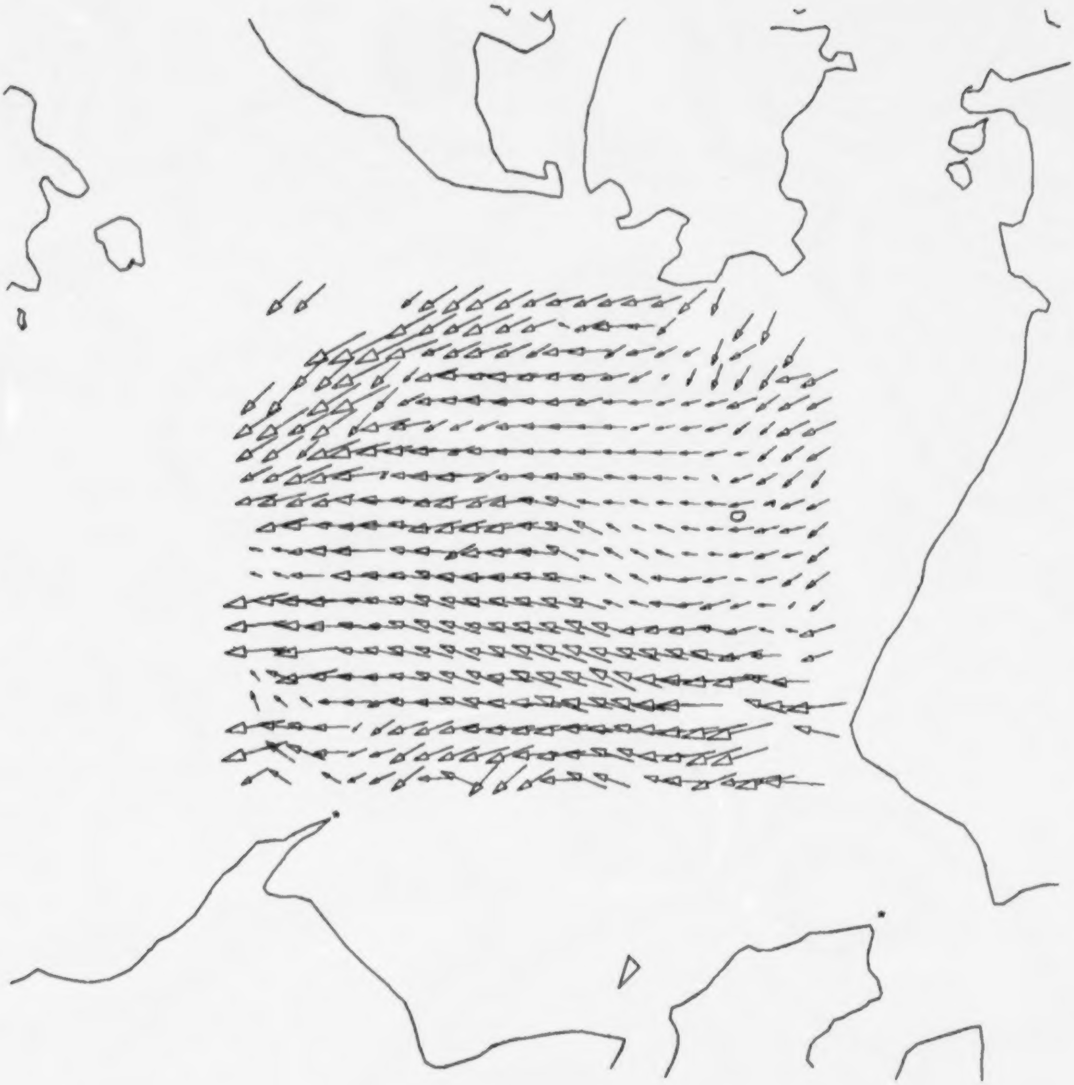
A 1.04


6 KM [------------]
200 CM/S [------------]
TRUE NORTH ↑

23 AUG 78   2: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.05

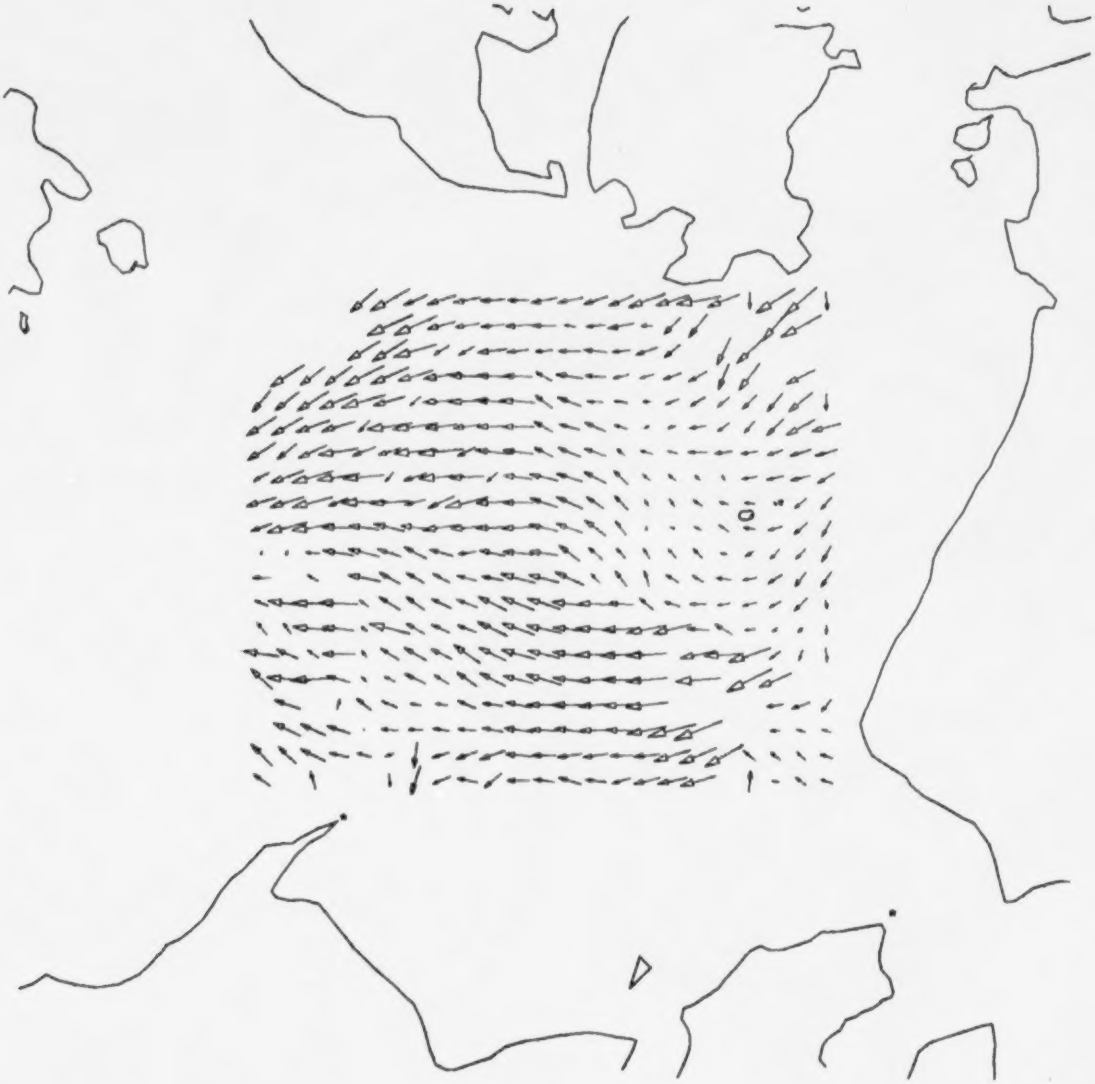


23 AUG 78 3: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

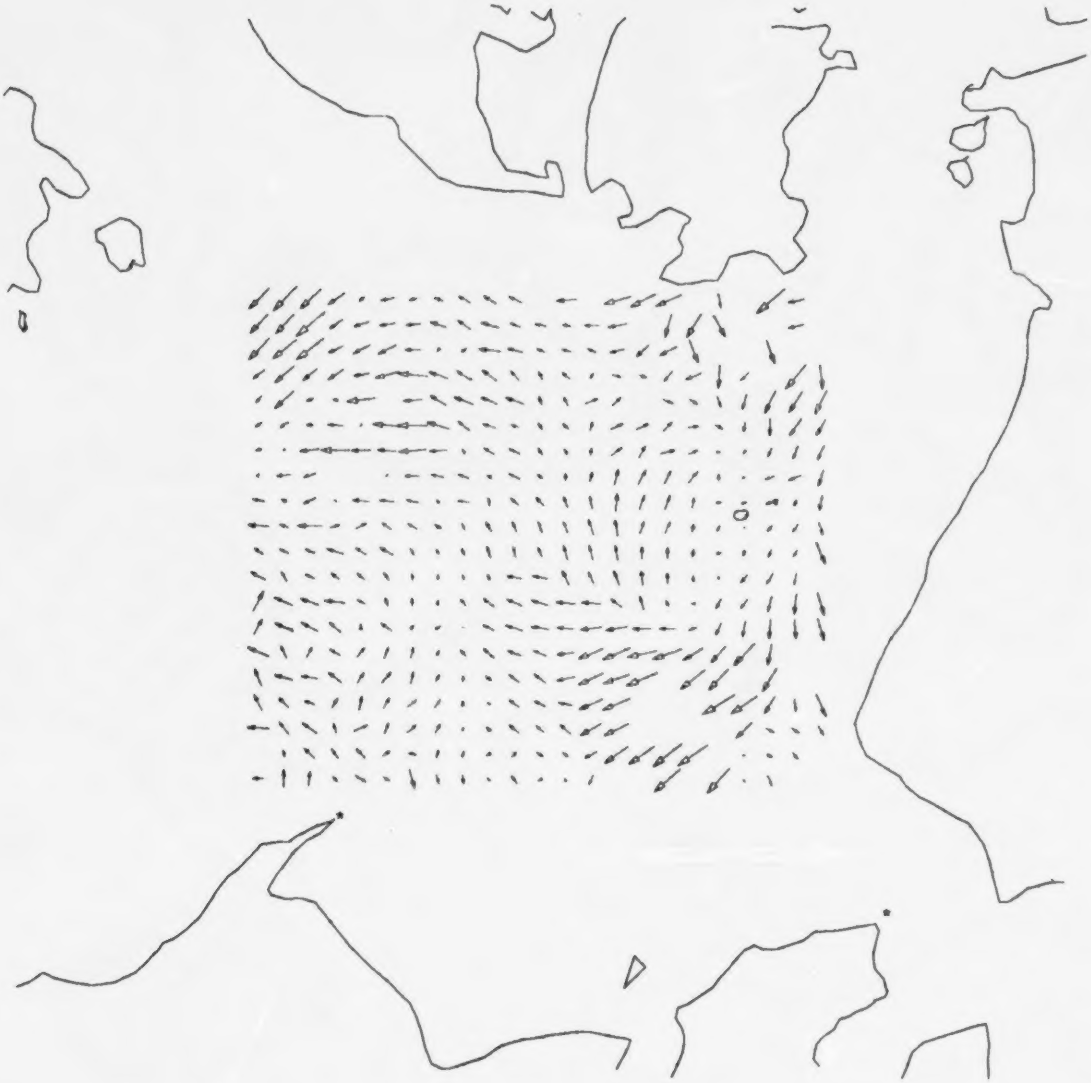
A 1.06



23 AUG 78 4: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [————————]
200 CM/S [————————]
TRUE NORTH ↑

A 1.V

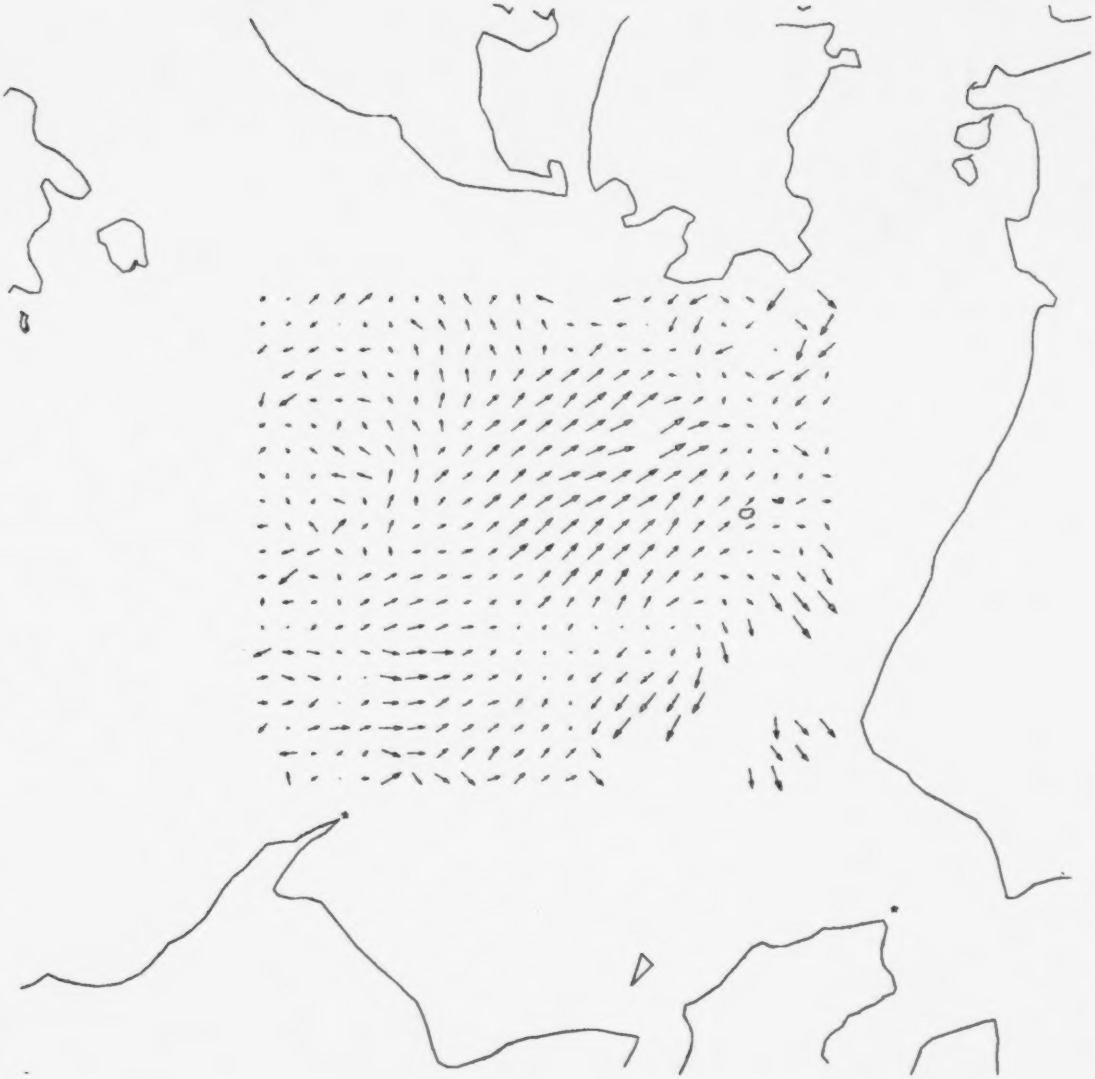


23 AUG 78   5: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

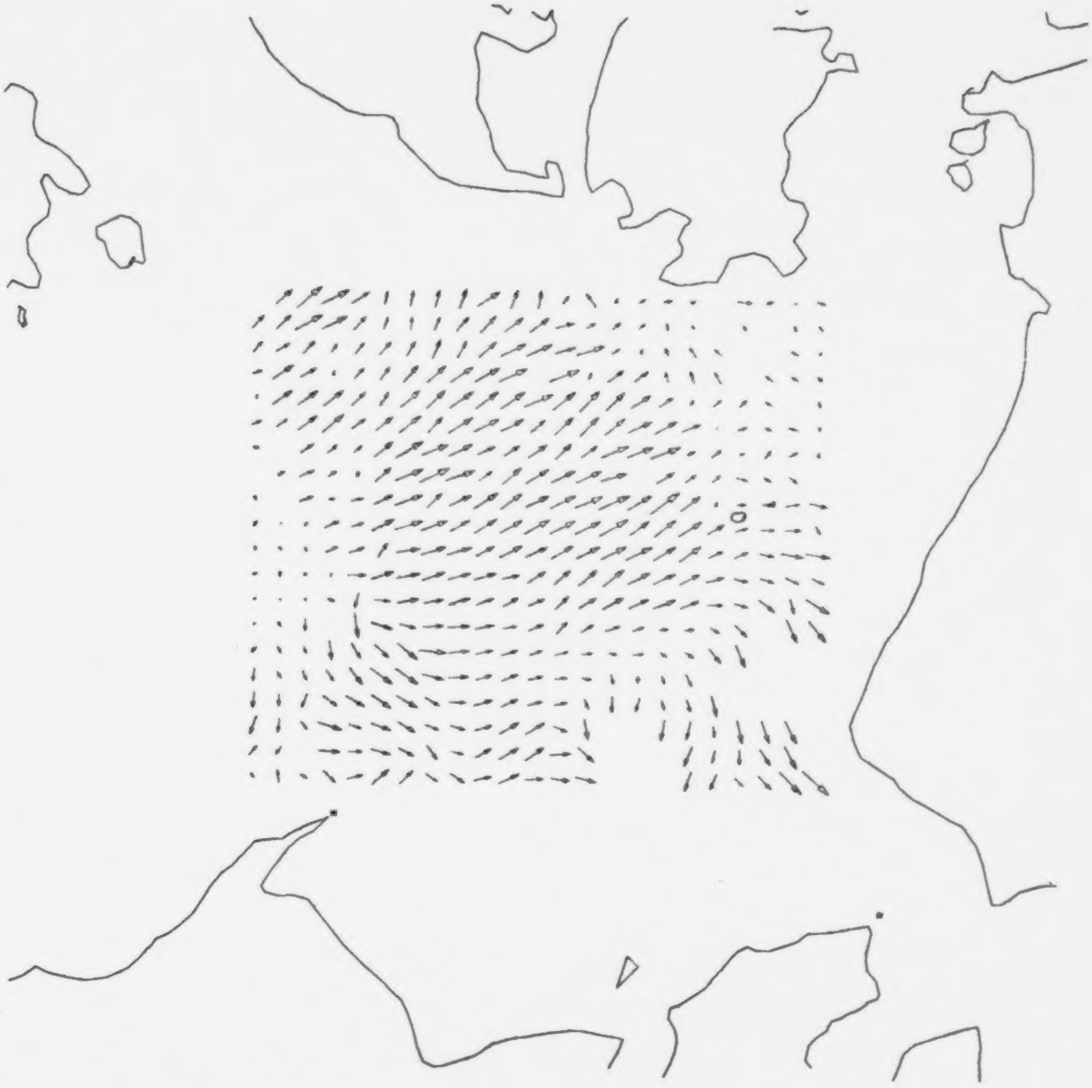
A 1.03



23 AUG 78 6: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [--------------]
200 CM/S [--------------]
TRUE NORTH ↑

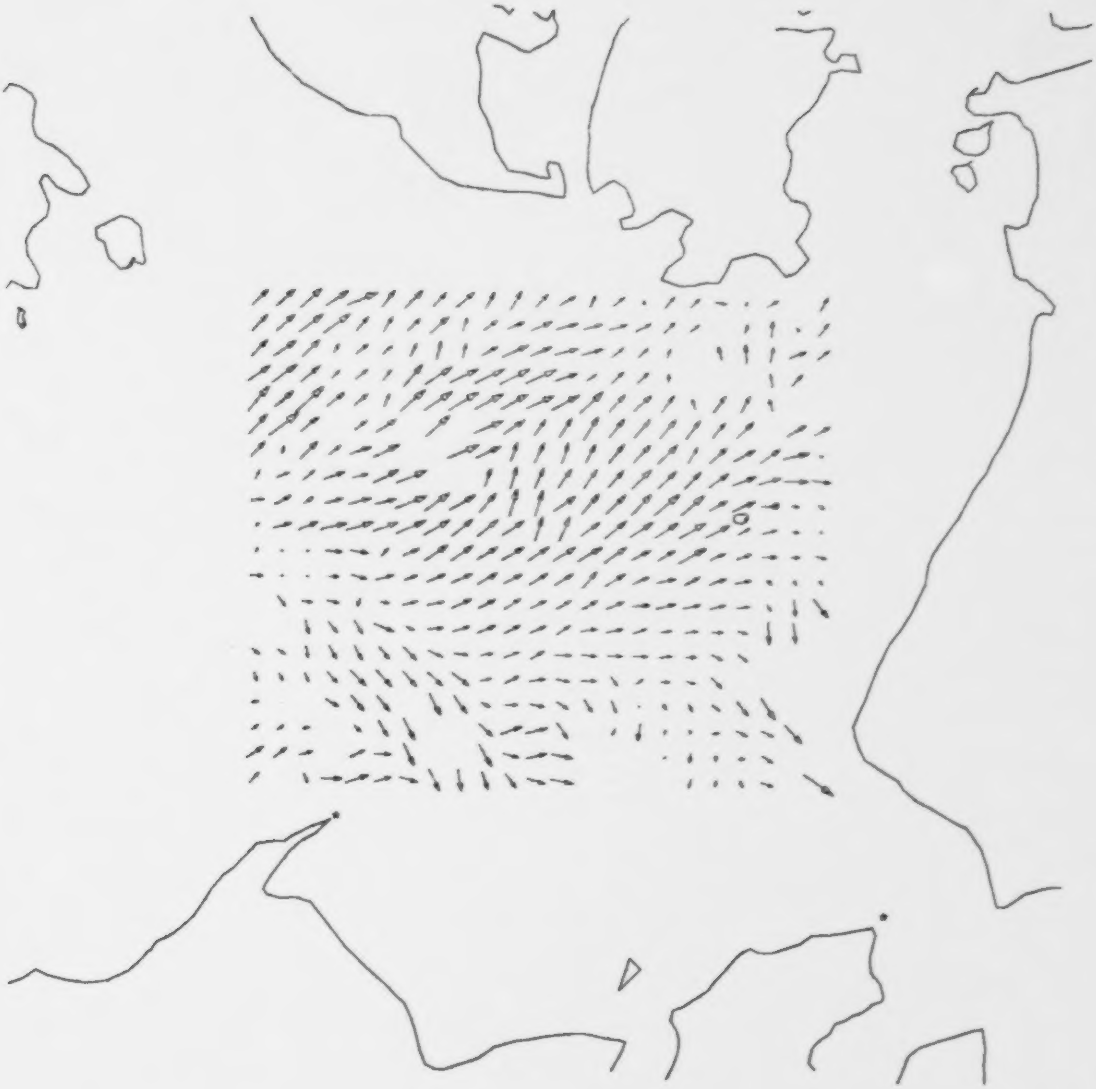
A 1.09



23 AUG 78   7: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.10

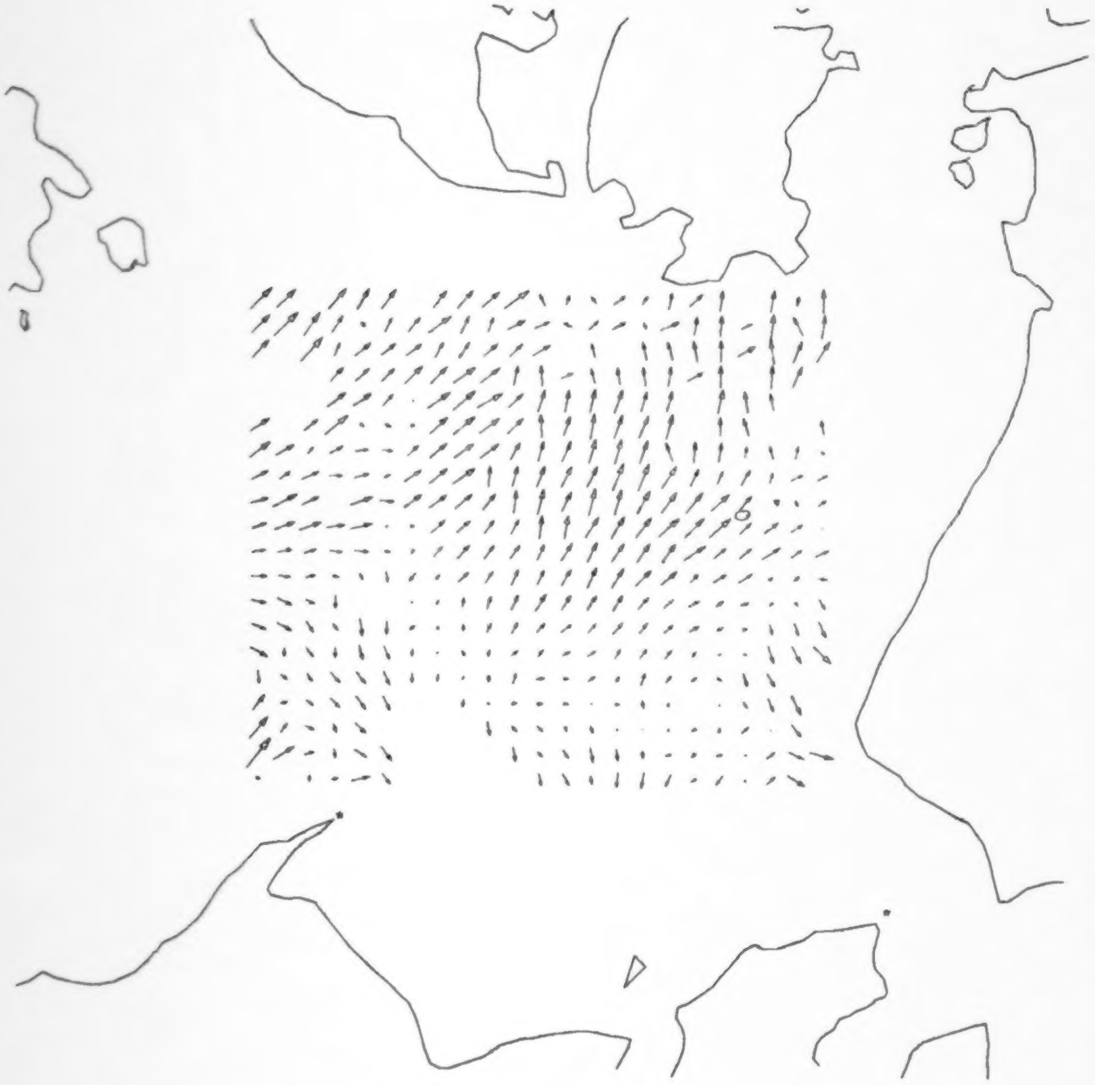


23 AUG 78 8: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

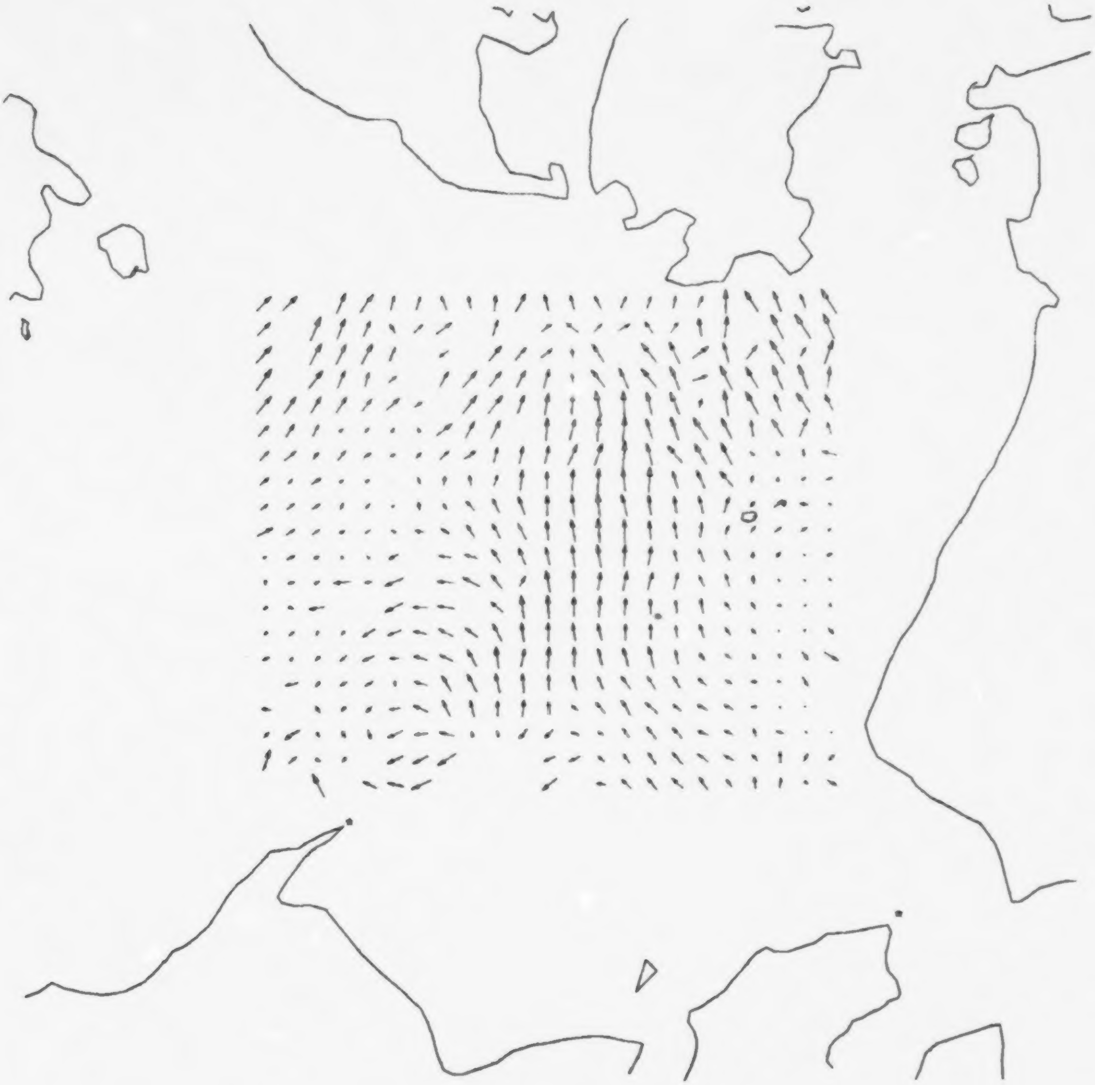
A 1.11



23 AUG 78 9: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [------------------]
200 CM/S [------------------]
TRUE NORTH ↑

A 1.12

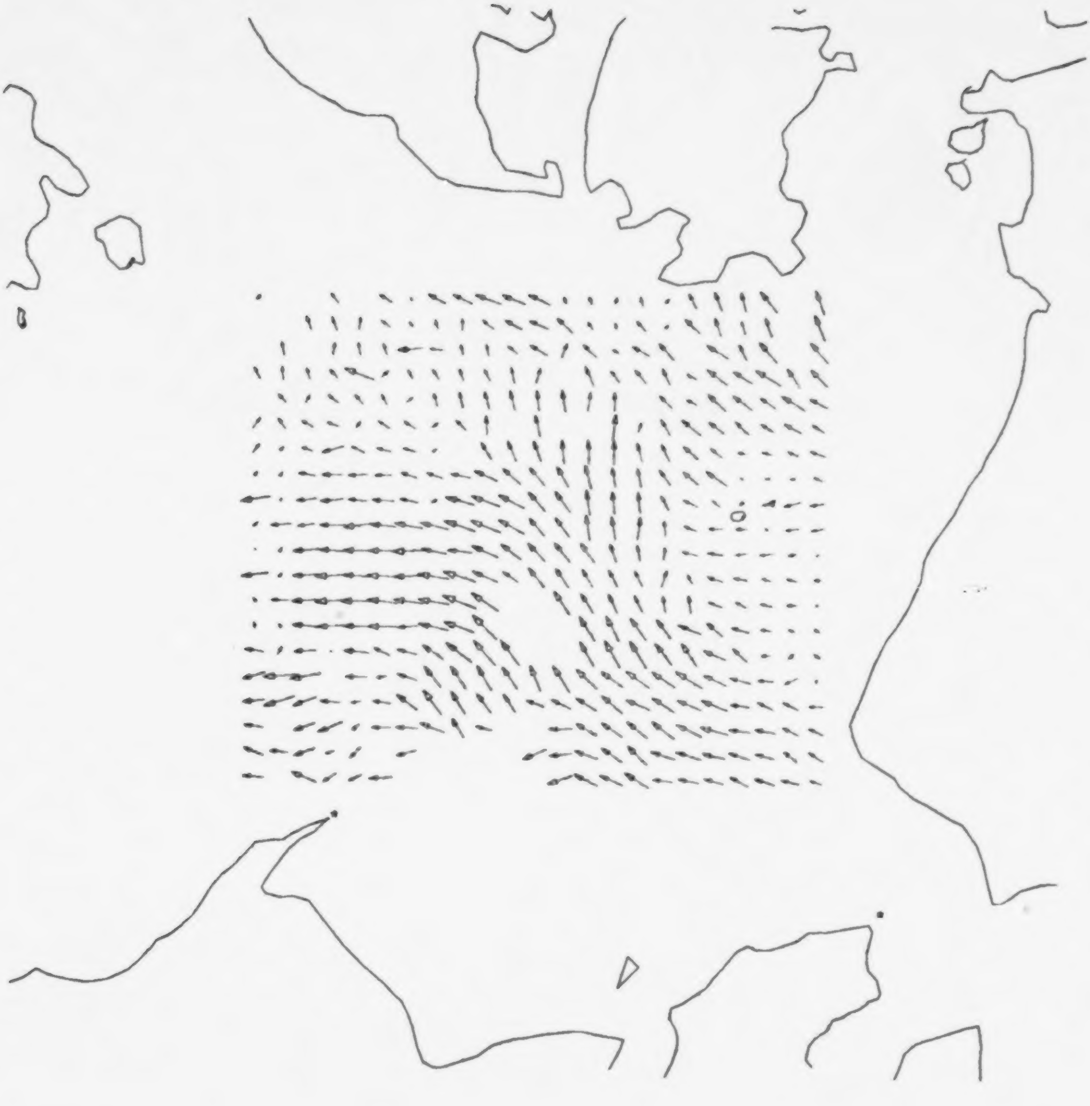


23 AUG 78 10: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [------------------]
200 CM/S [------------------]

TRUE NORTH ↑

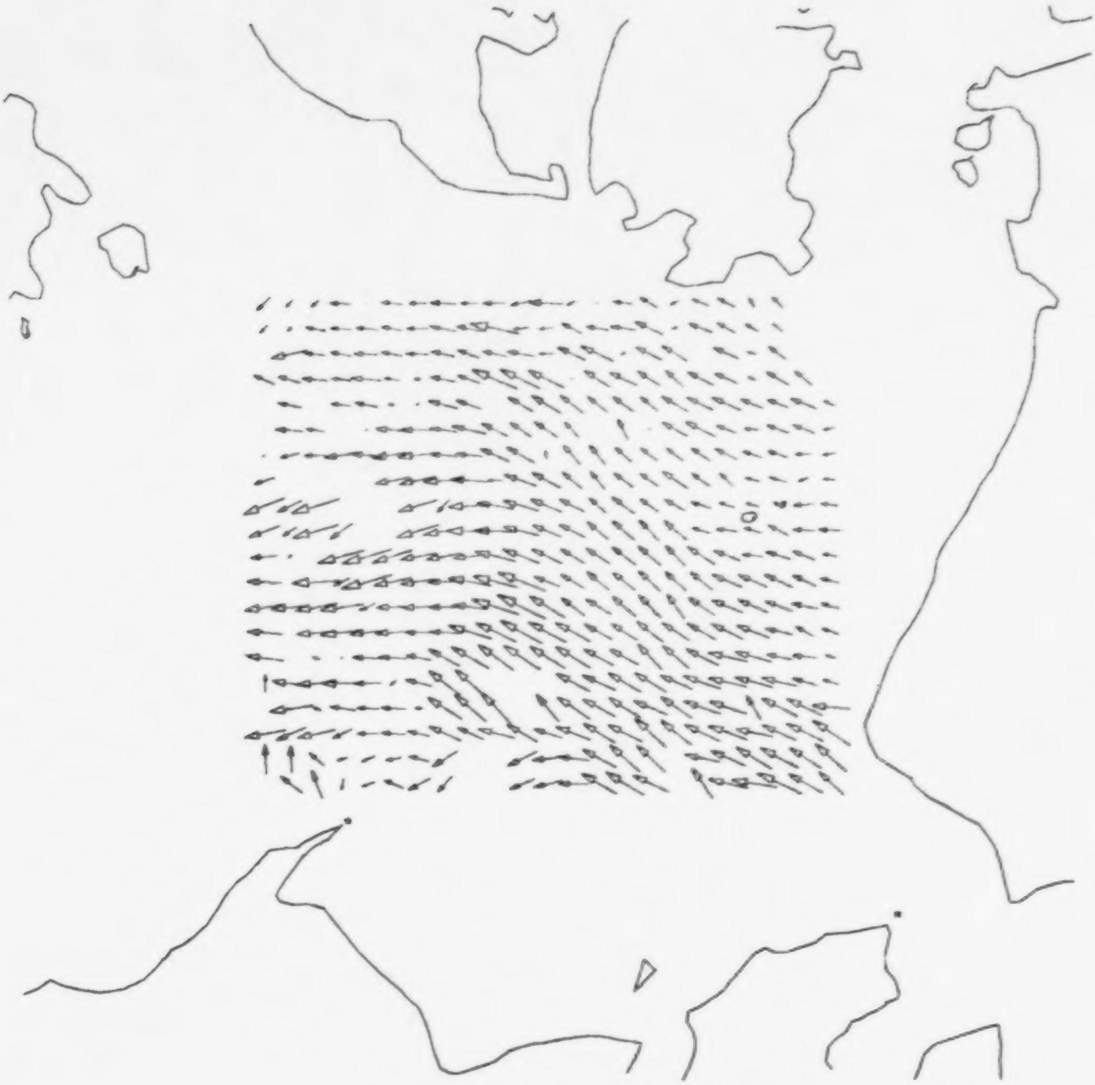
A 1.13



23 AUG 78 11: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.14

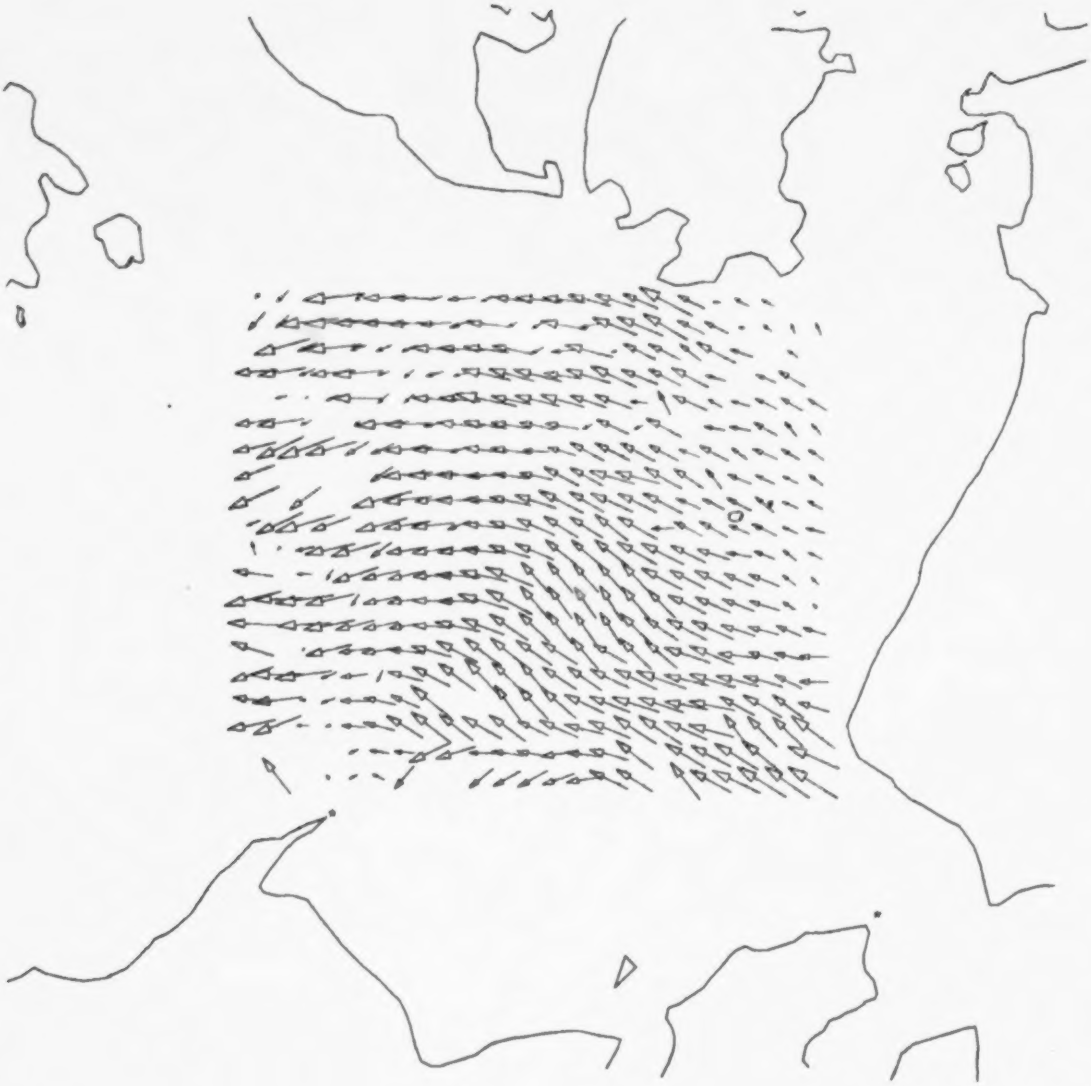


23 AUG 78 12: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 1.15

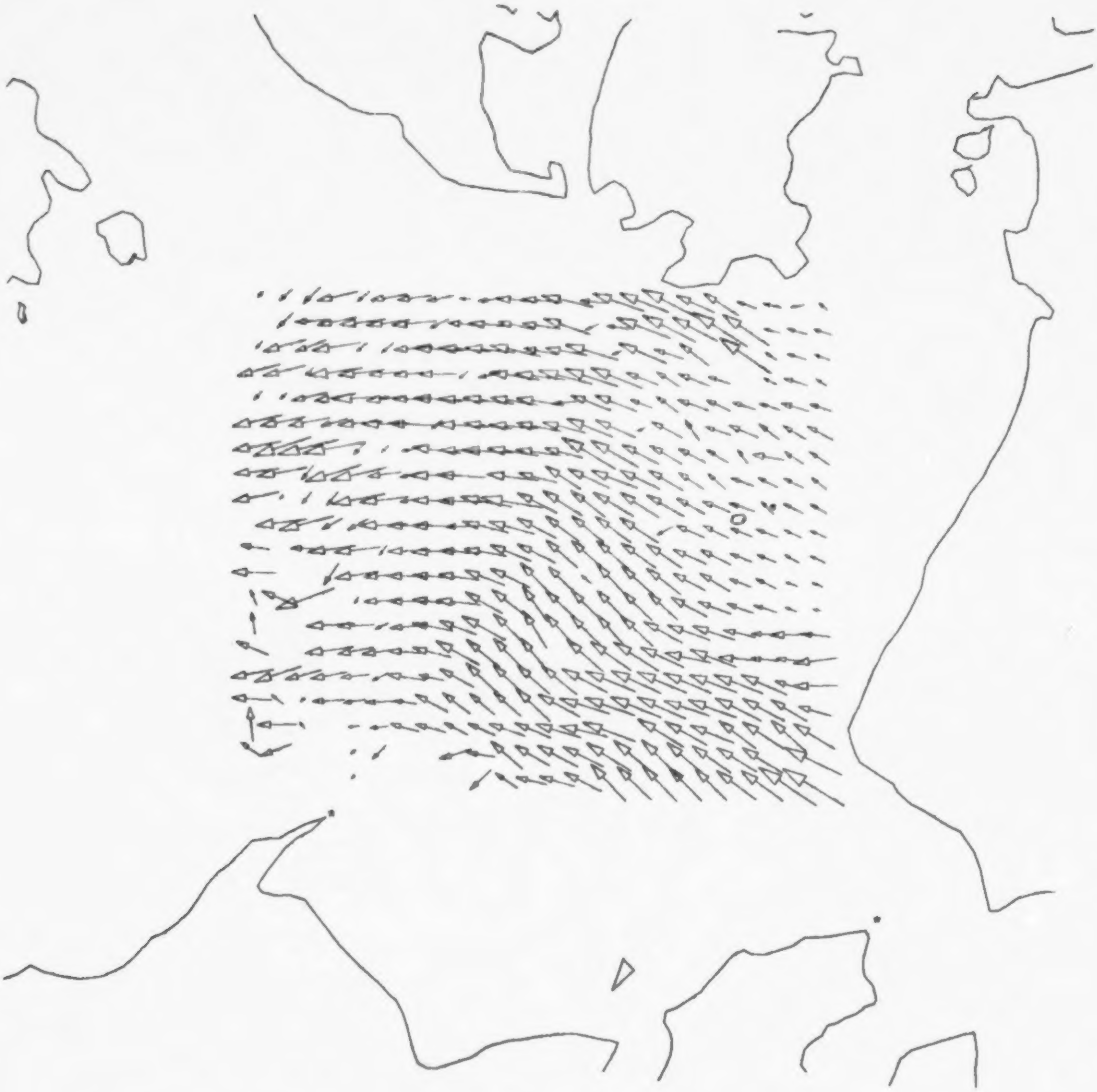


23 AUG 78 13: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [--------------------]
200 CM/S [--------------------]

TRUE NORTH ↑

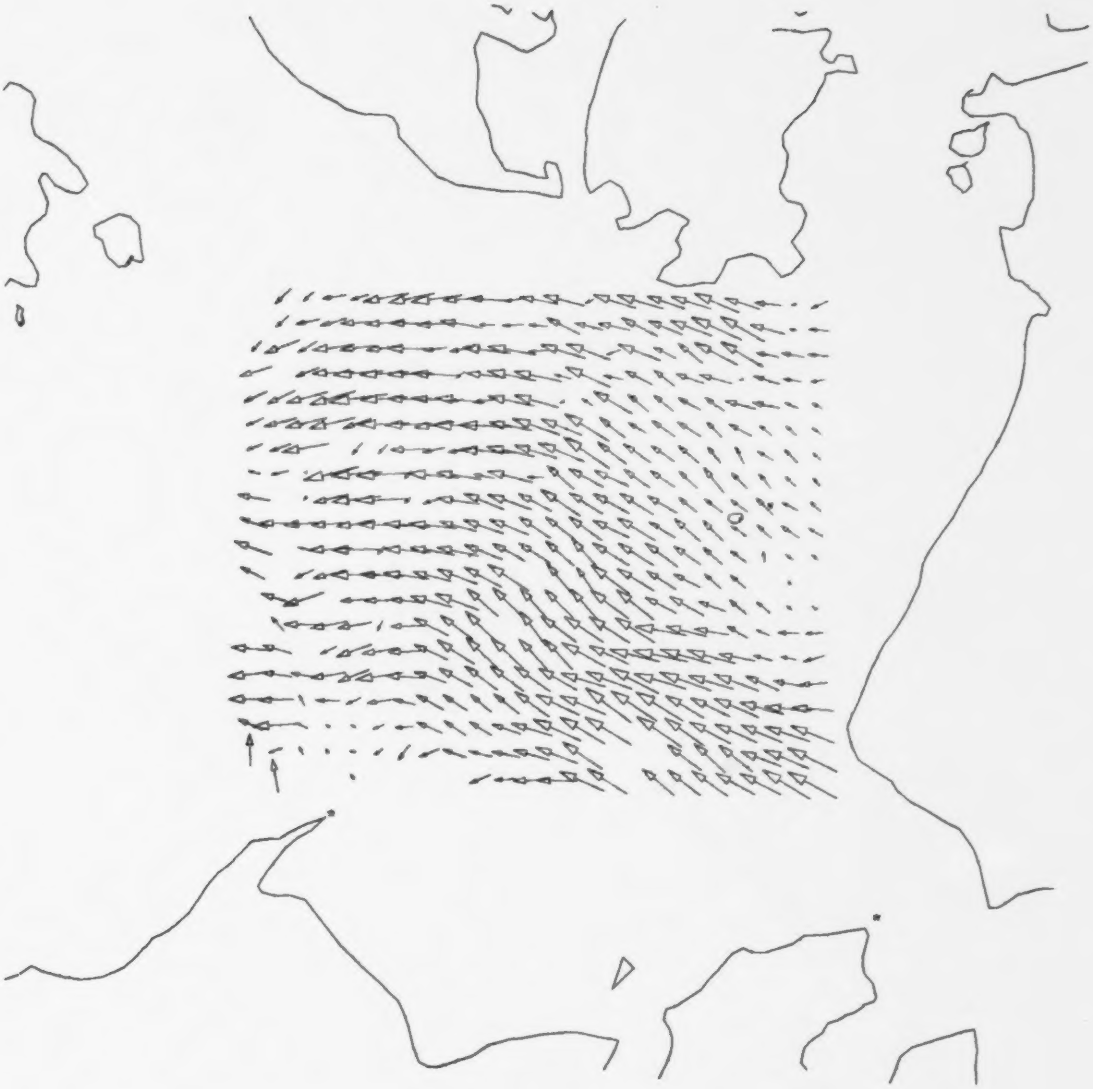
A 1.16



23 AUG 78 14: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [————————]
200 CM/S [————————]
TRUE NORTH ↑

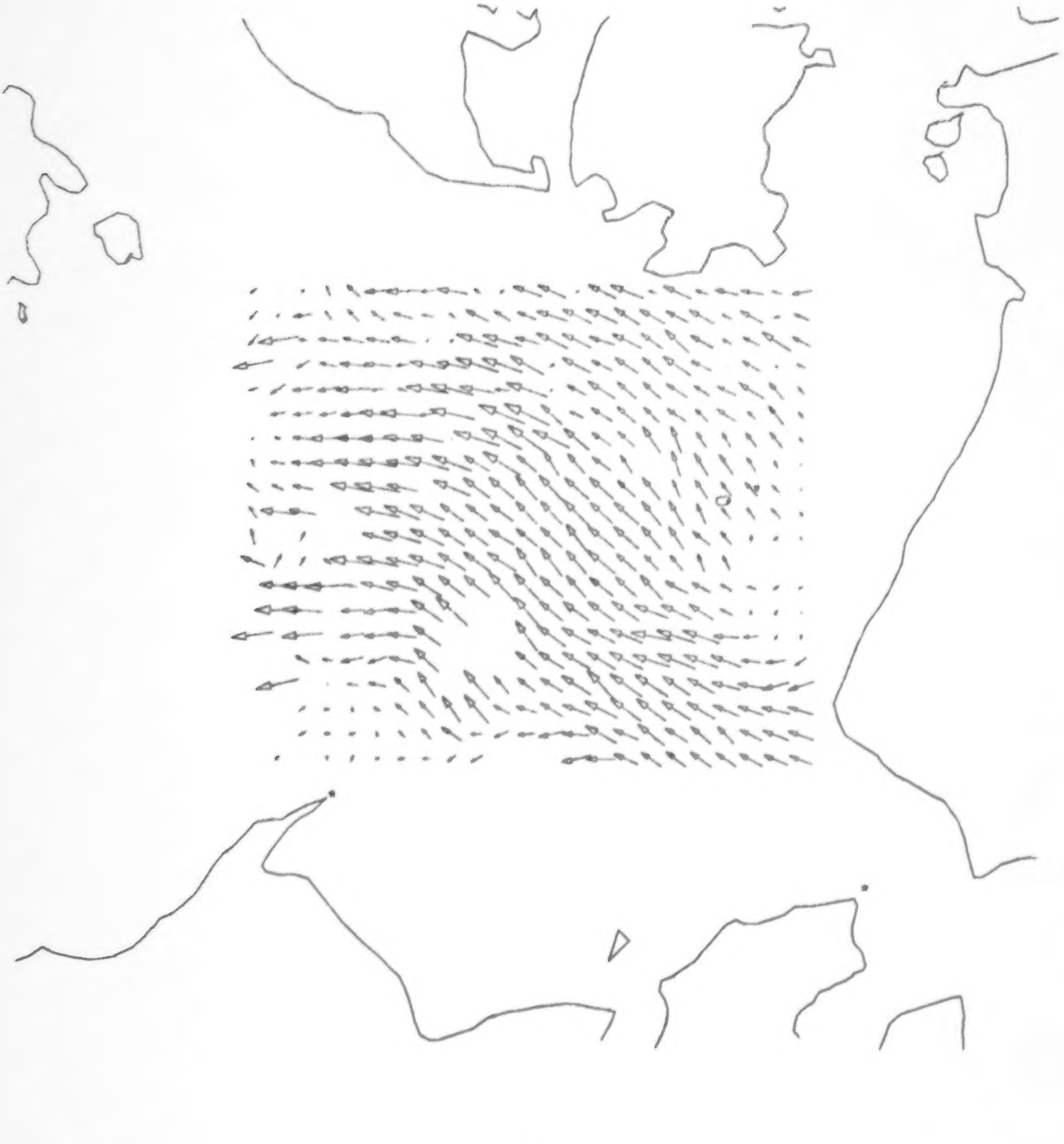
A 1.17



23 AUG 78 15: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

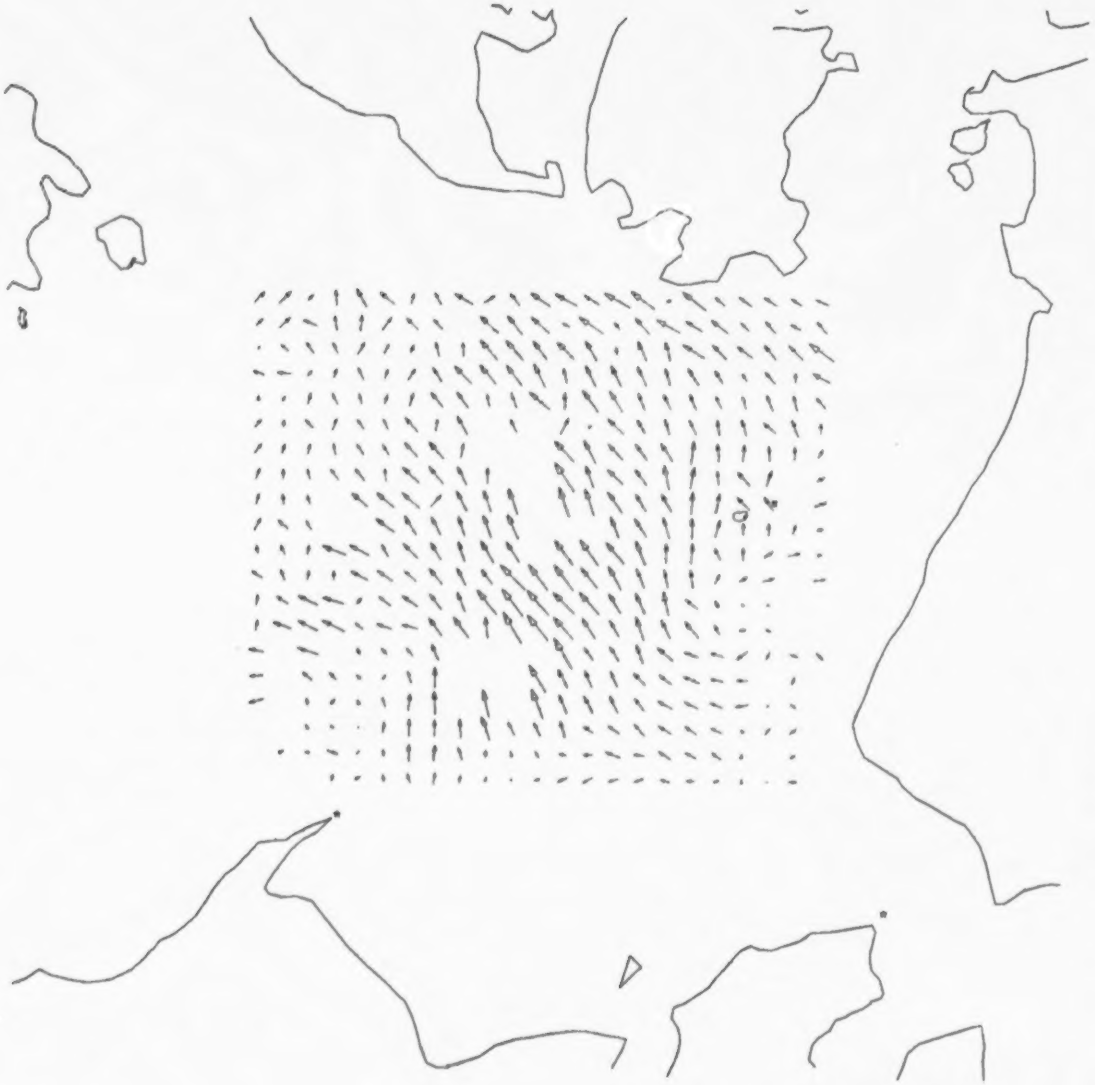
A 1.13



23 AUG 78 16: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

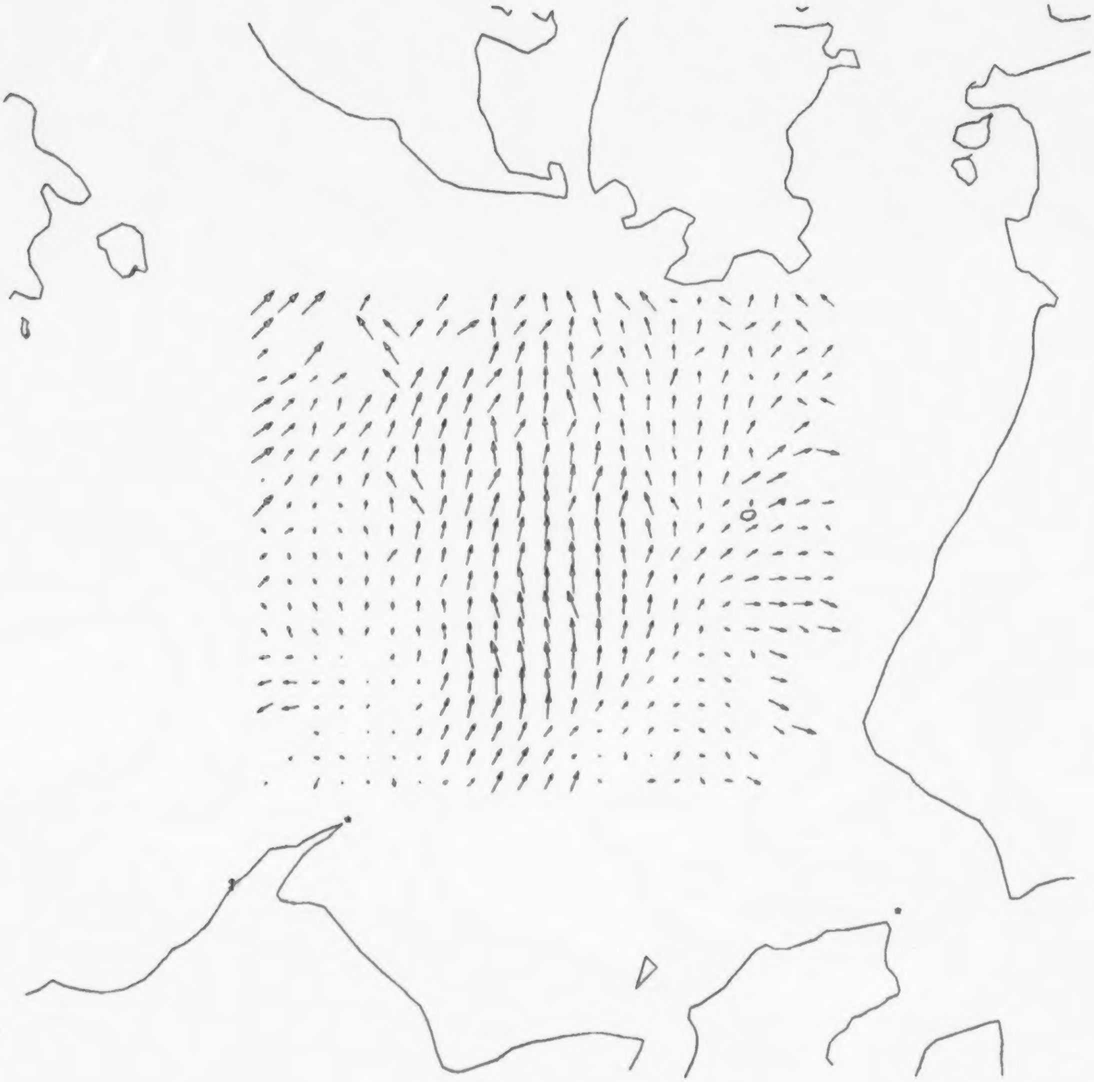
A 1.13



23 AUG 78 17: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

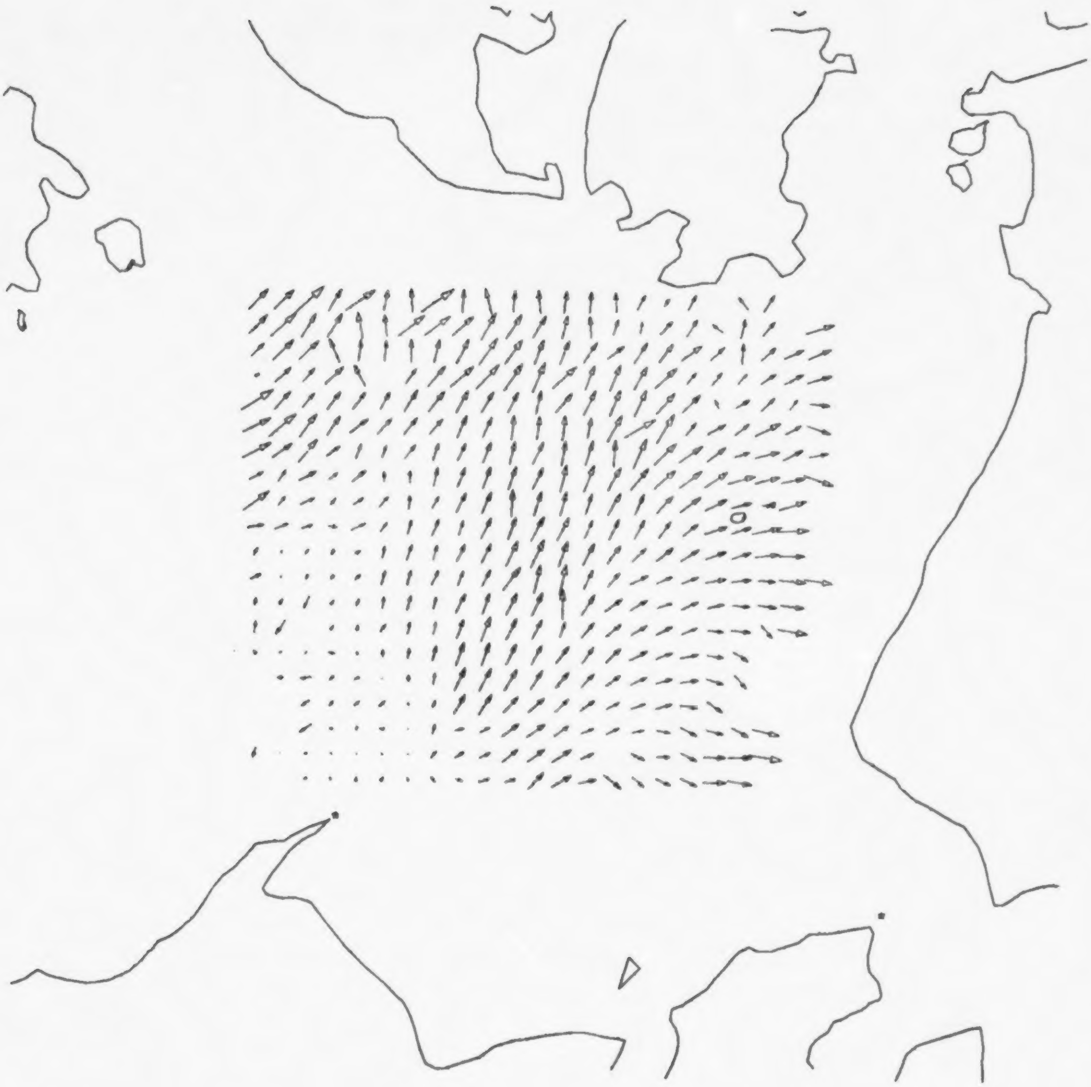
A 1.20



23 AUG 78 18: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

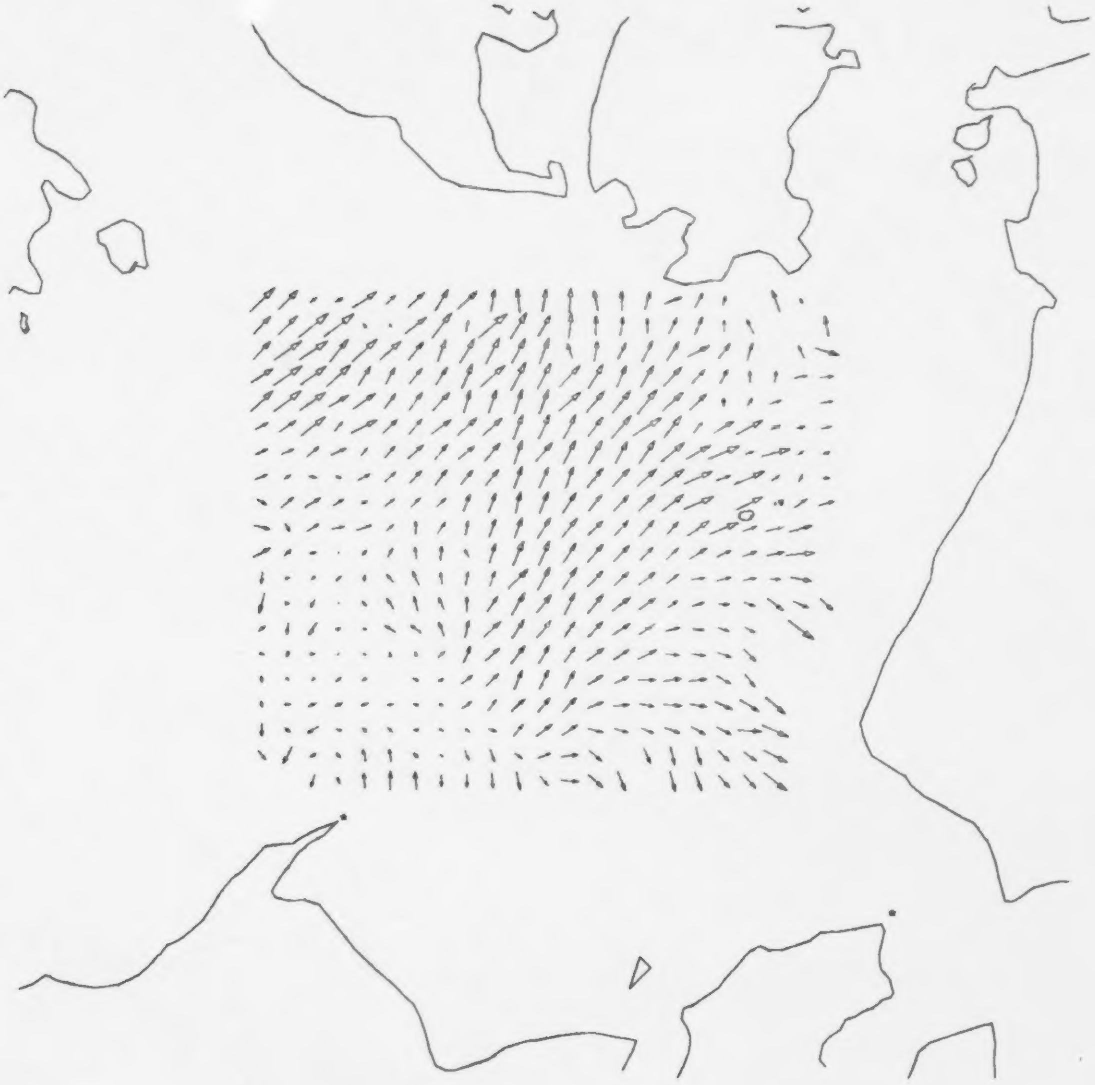
A 1.21



23 AUG 78 19: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [------------]
200 CM/S [------------]
TRUE NORTH ↑

A 1.22

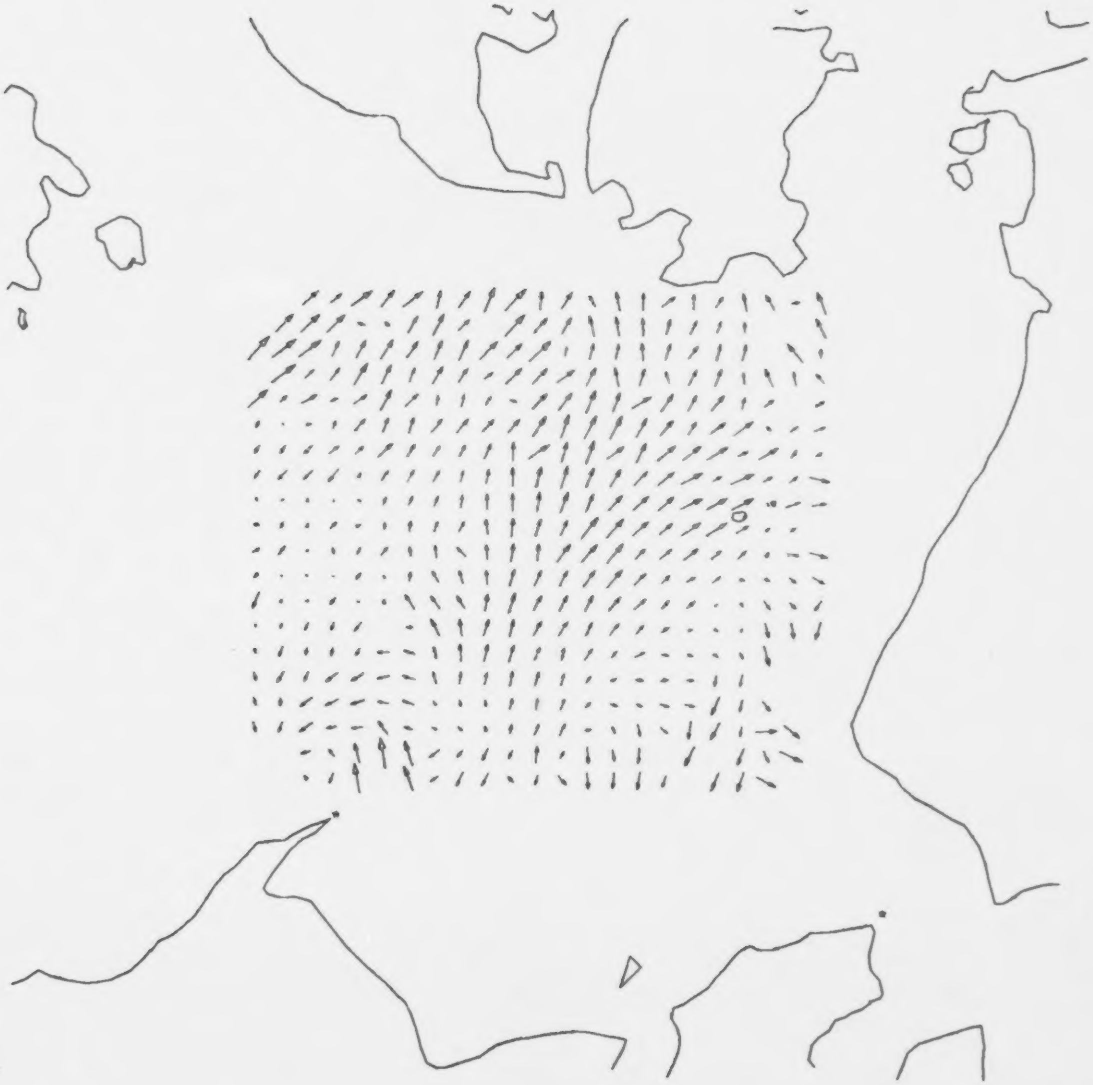


23 AUG 78 20: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [-------------------]
200 CM/S [-------------------]

TRUE NORTH ↑

A 1.23

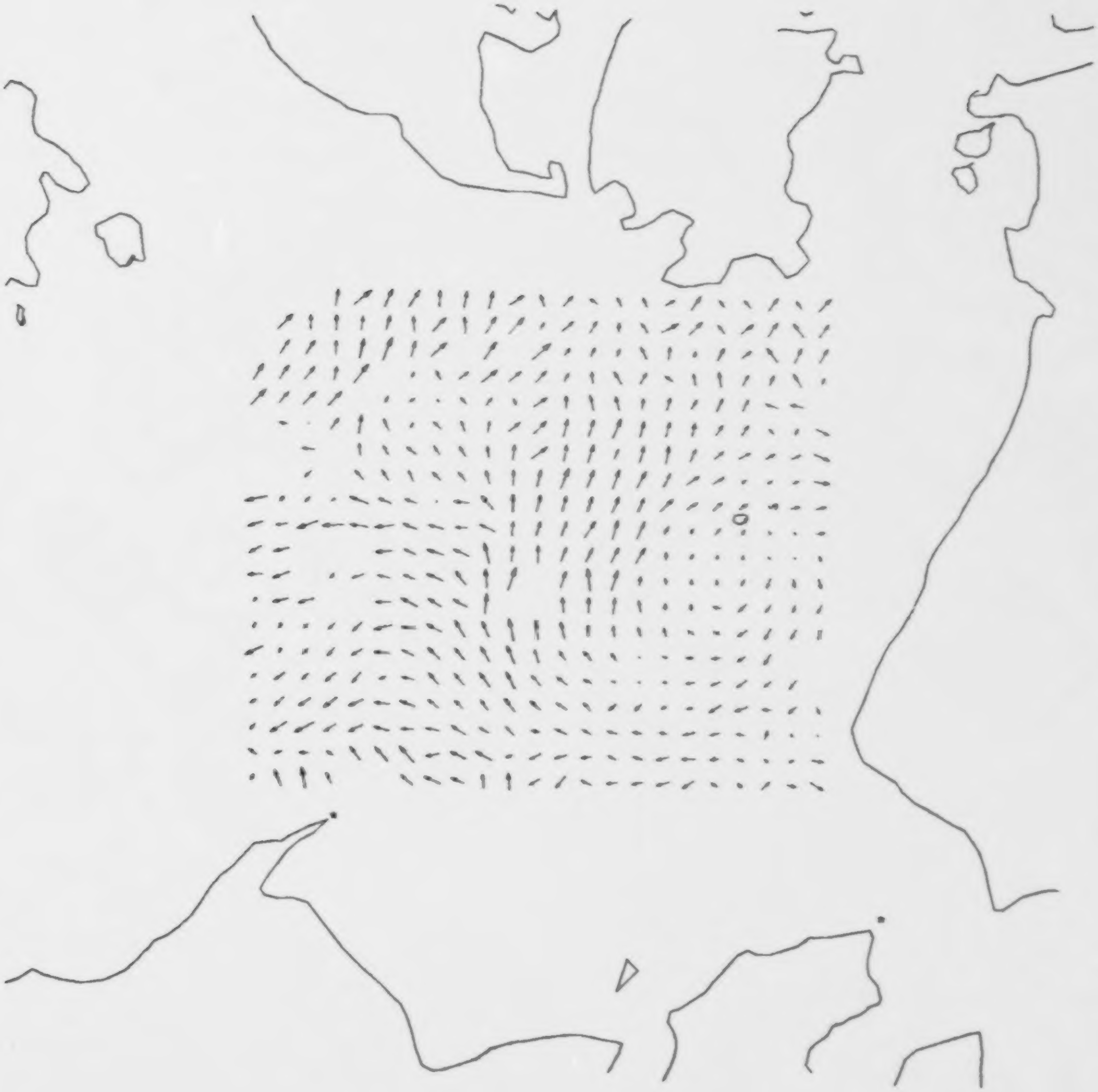


23 AUG 78 21: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 1.24

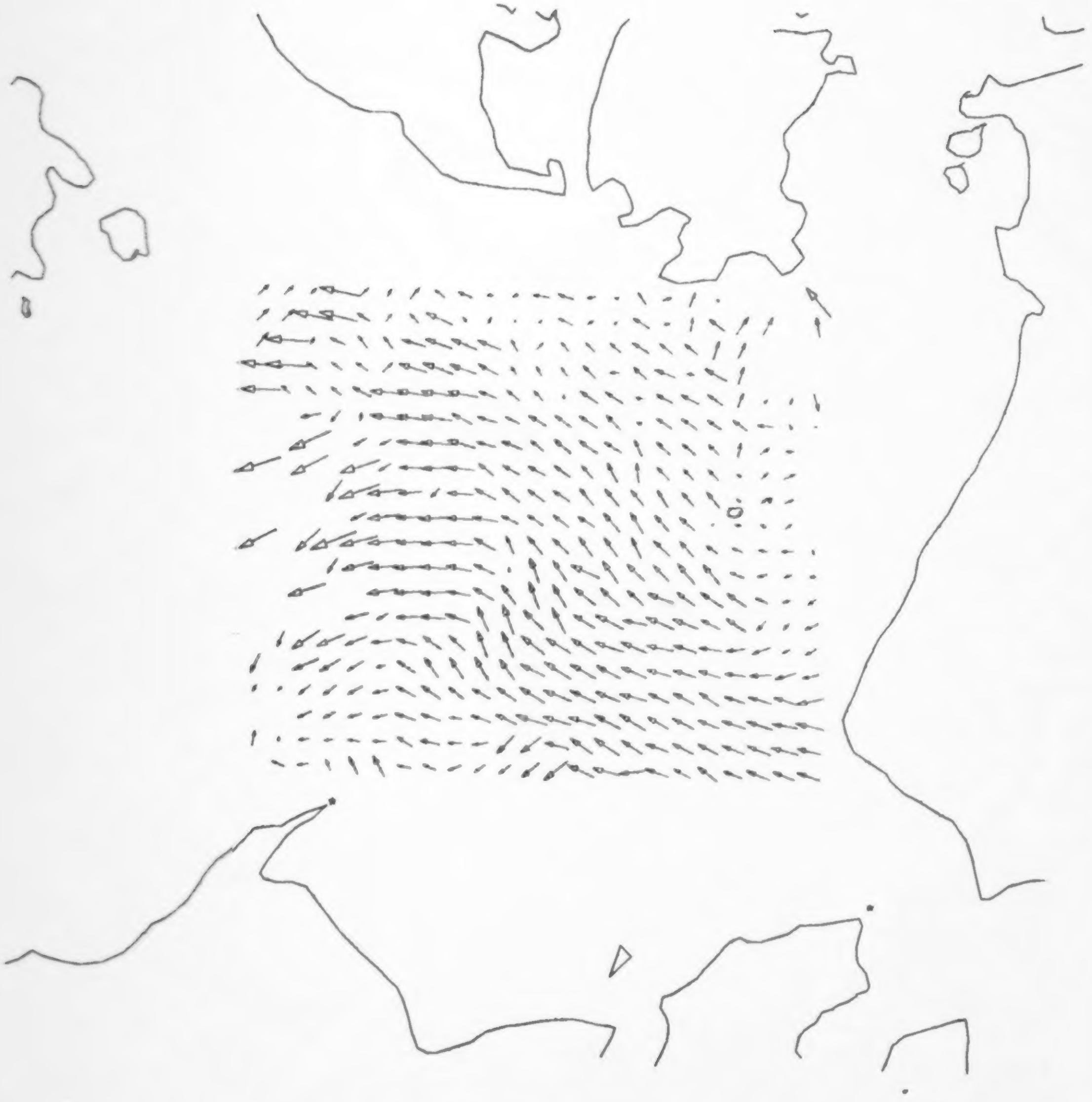


23 AUG 78 22: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 1.25

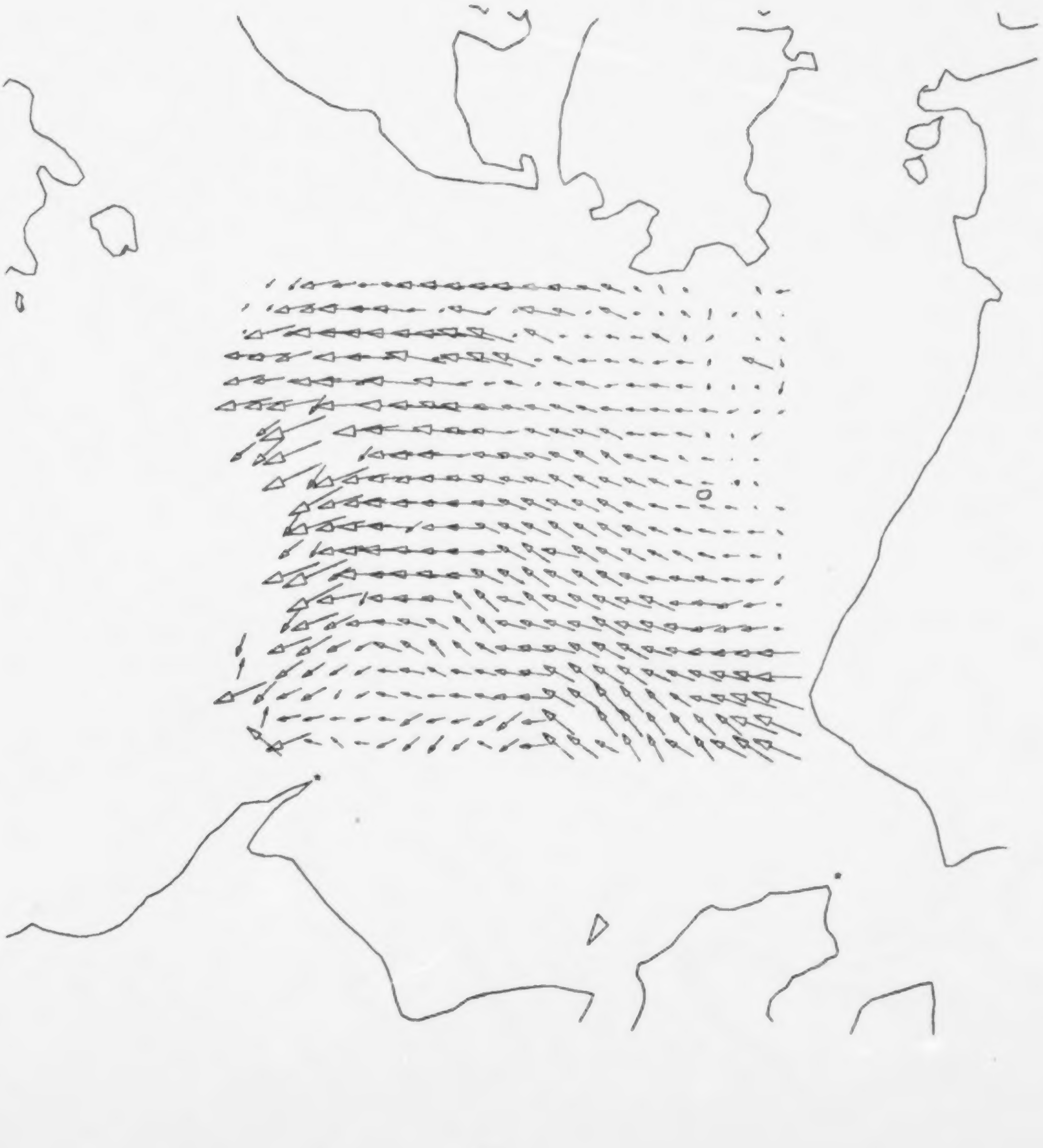


23 AUG 78 23: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [—————————]
200 CM/S [—————————]

TRUE NORTH ↑

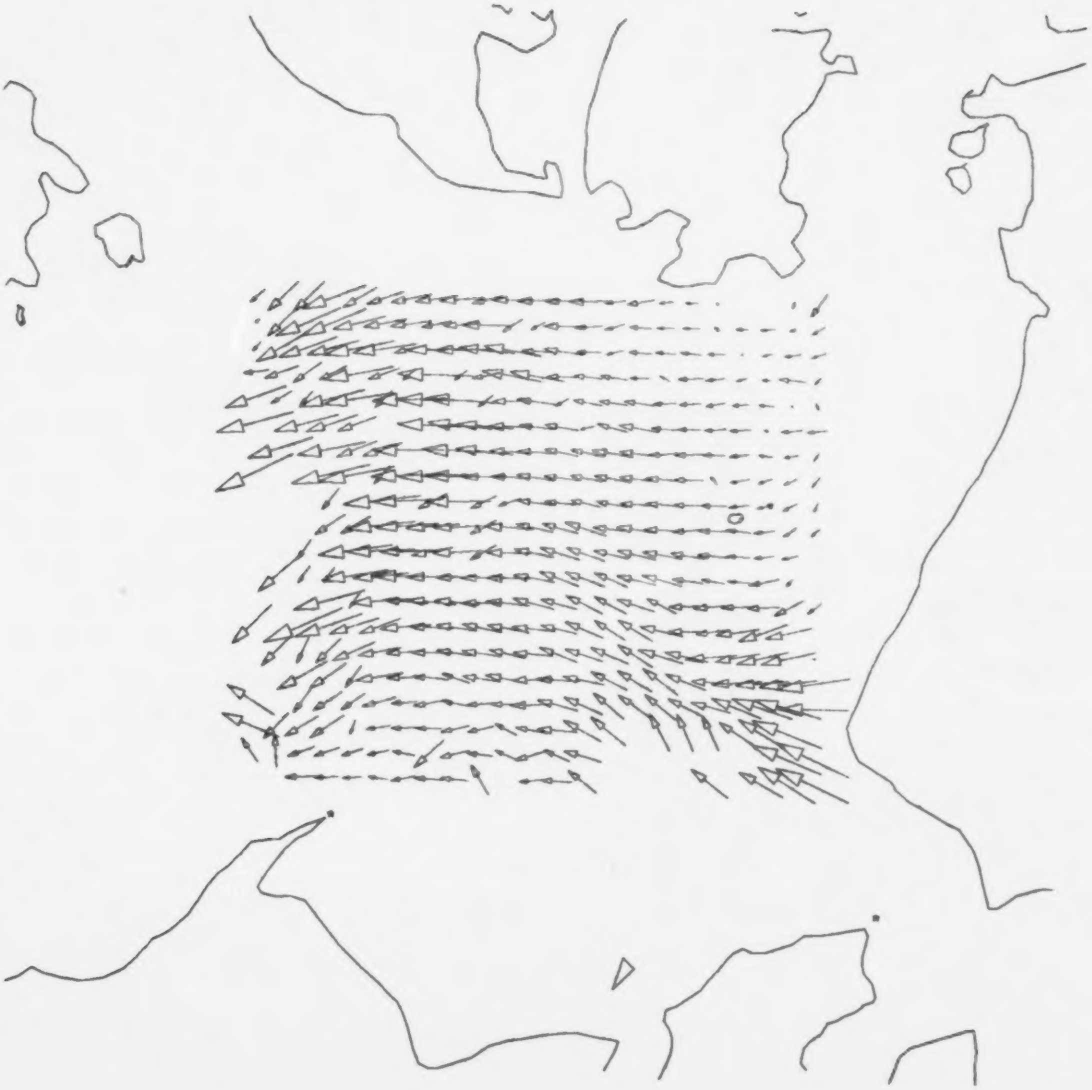
A 1.26



24 AUG 78   0: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.27

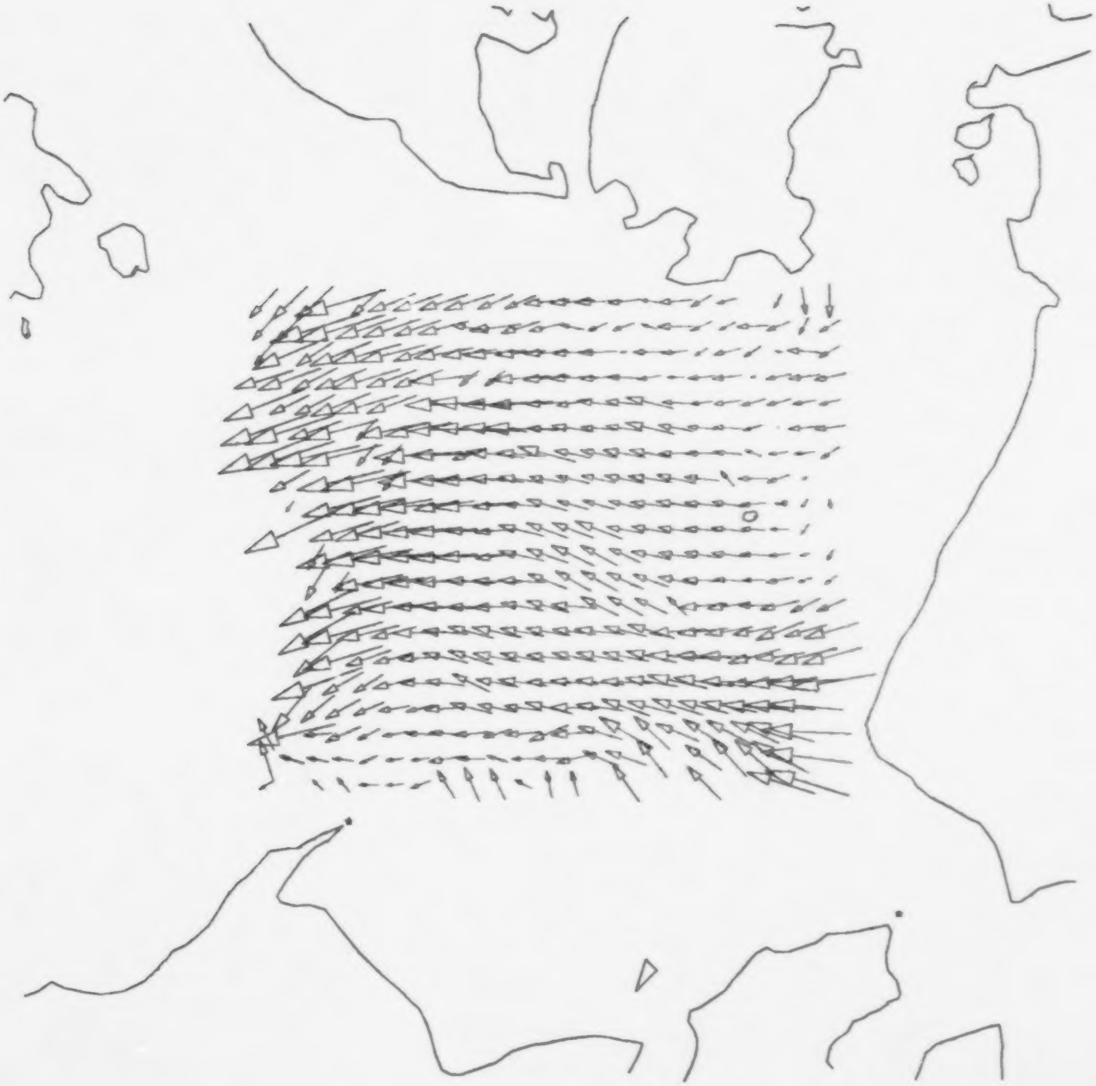


24 AUG 78   1: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

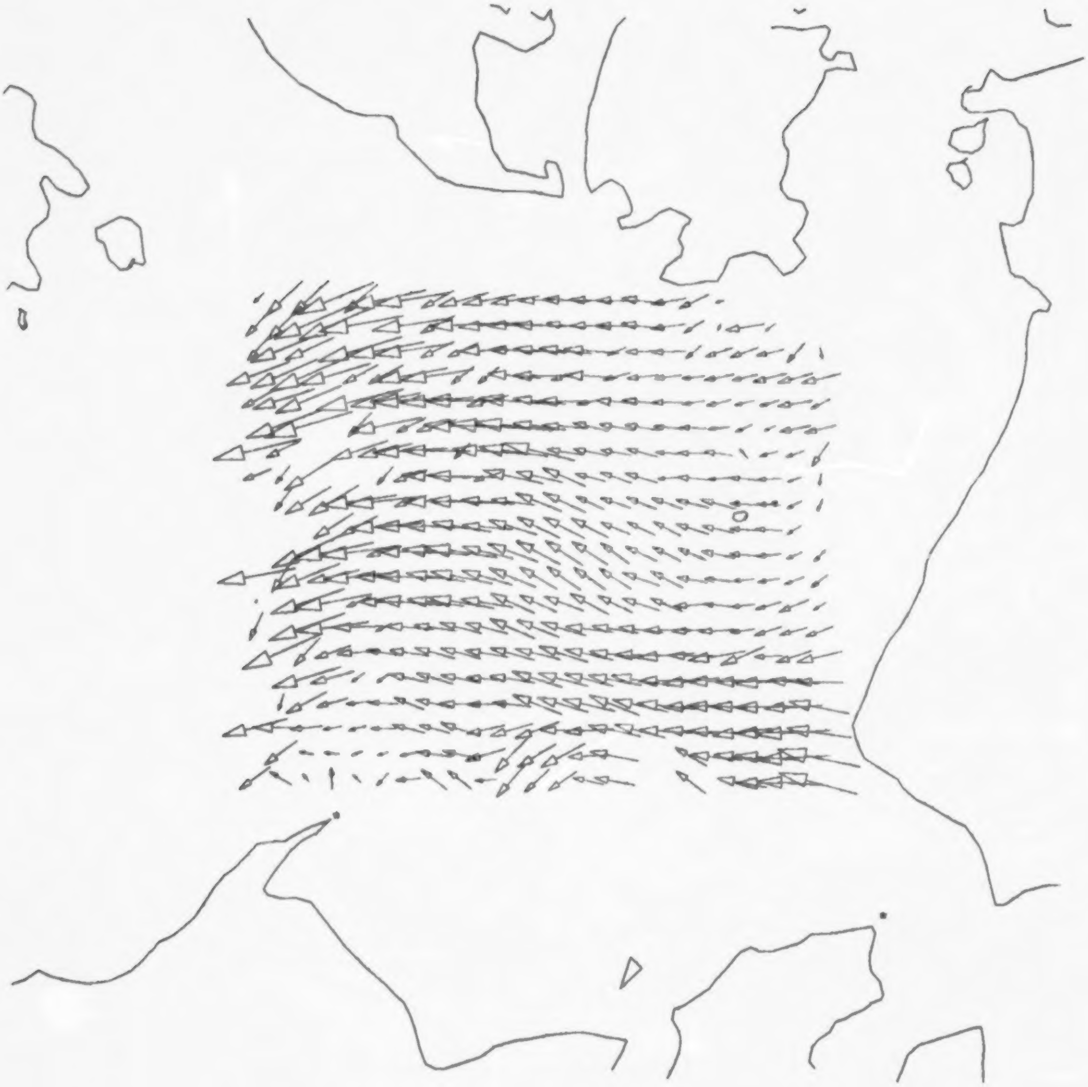
A 1.23



24 AUG 78 2: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.29

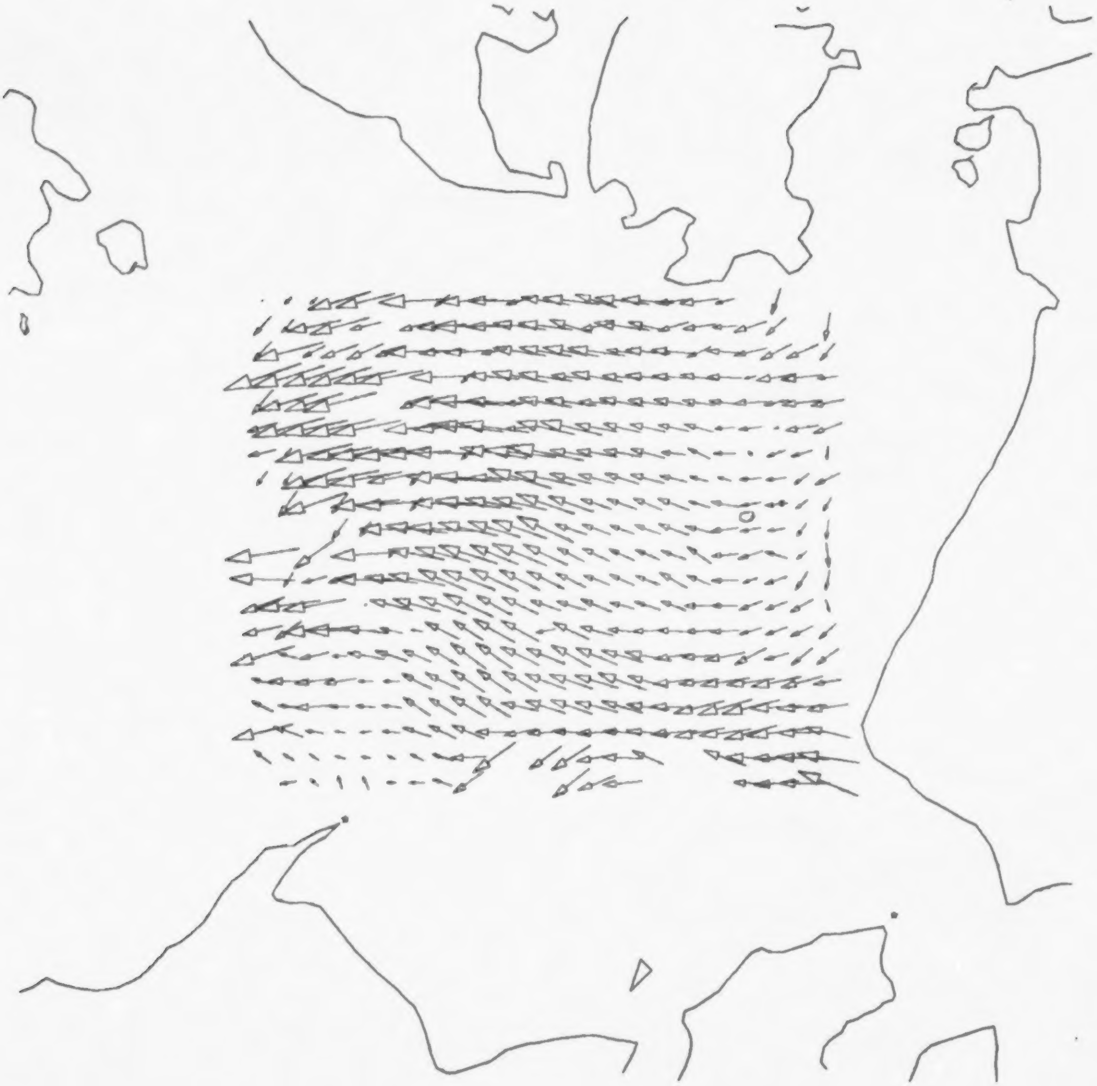


24 AUG 78   3: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

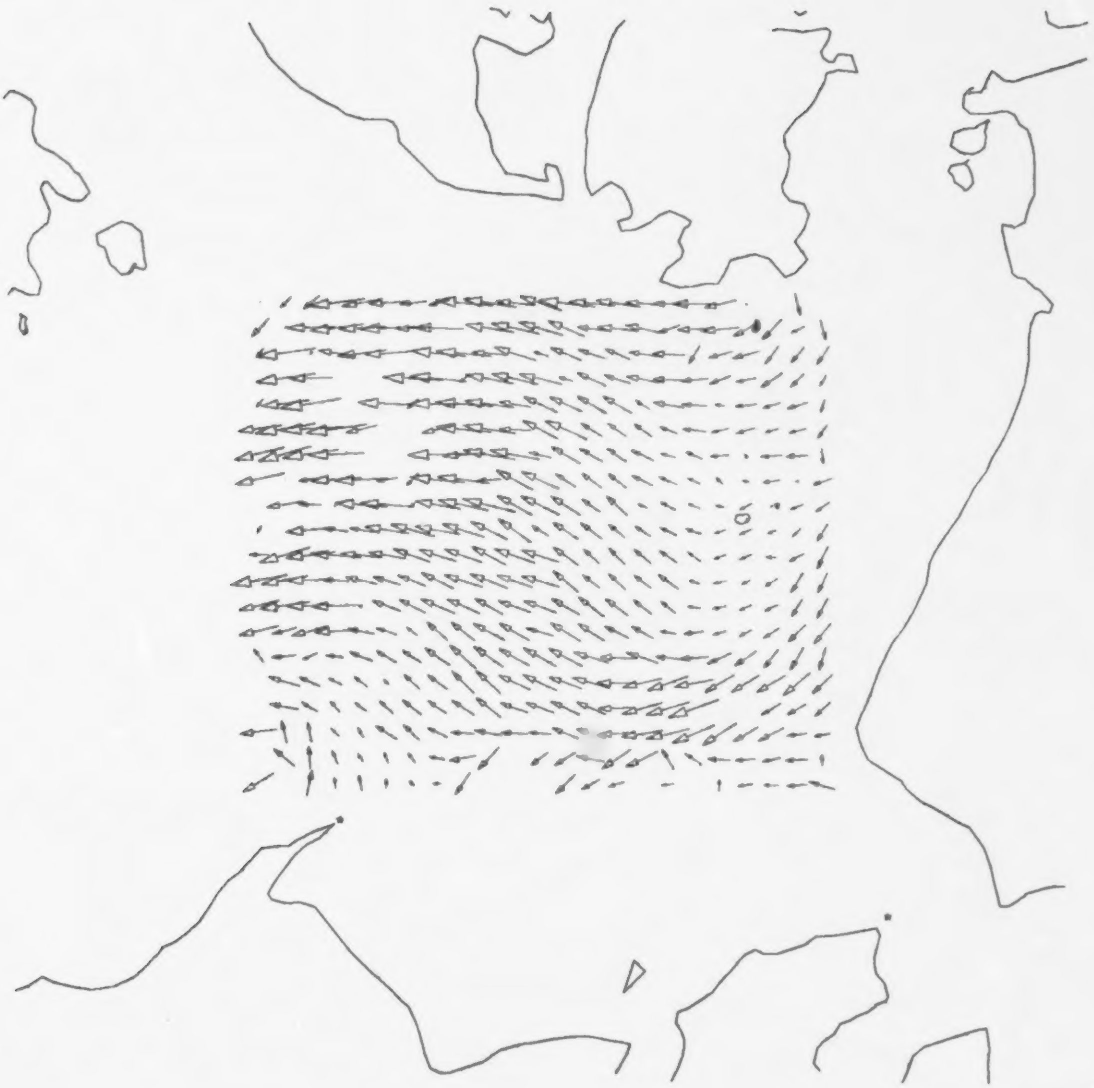
A 1.30



24 AUG 78 4: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [――――――――]
200 CM/S [――――――――]
TRUE NORTH ↑

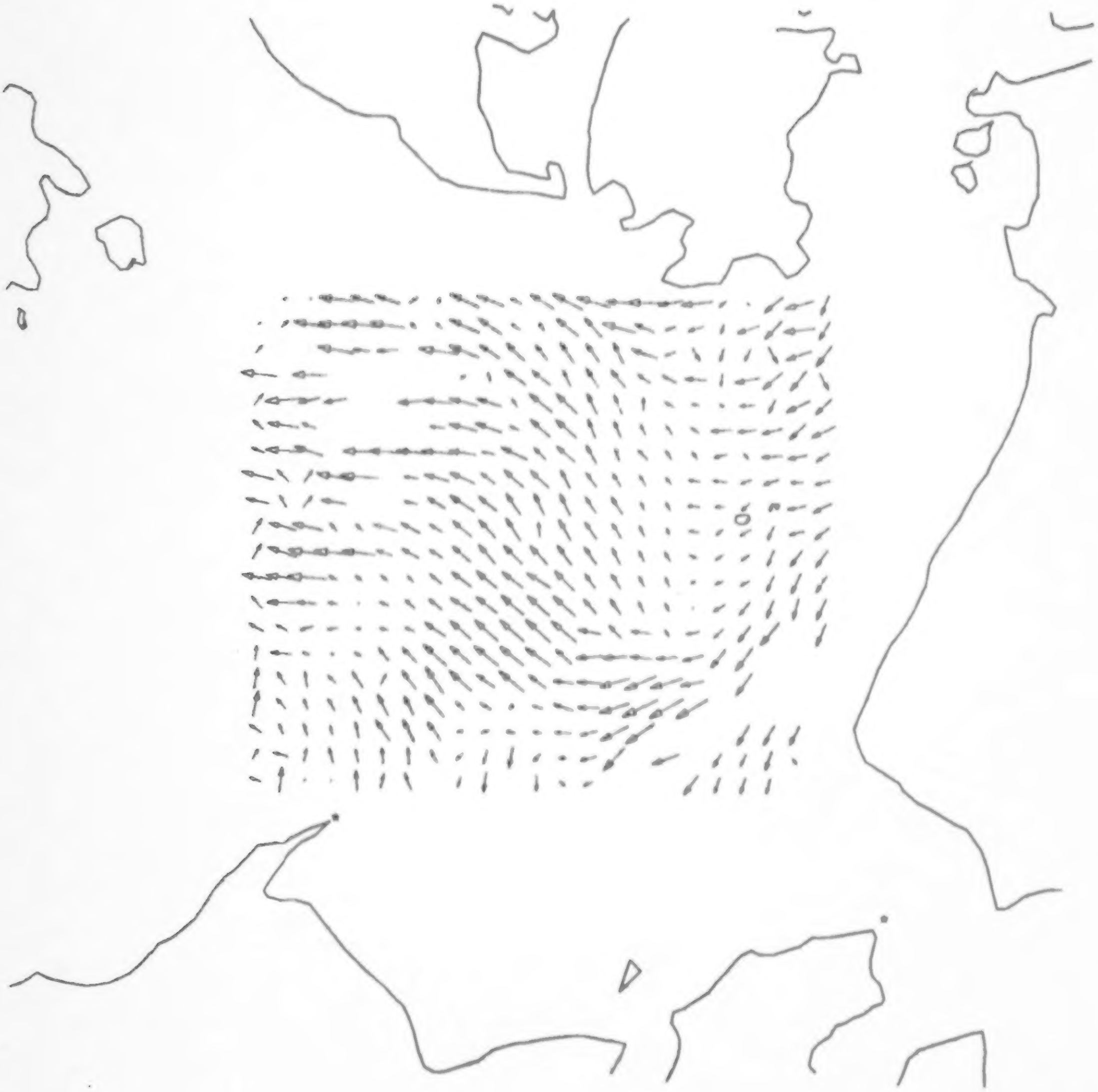
A 1.31



24 AUG 78 5: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [――――――]
200 CM/S [――――――]
TRUE NORTH ↑

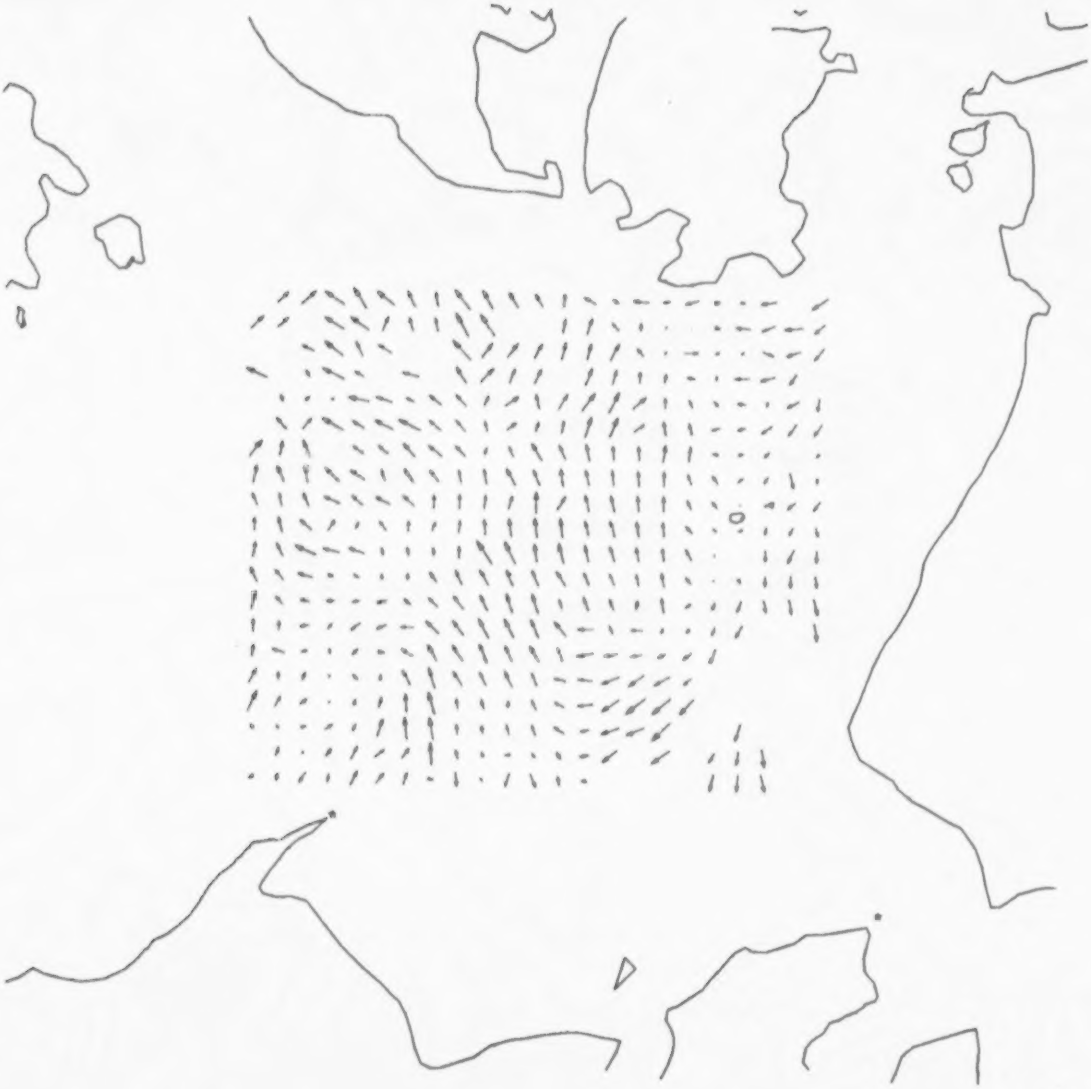
A 1.32



24 AUG 78 6: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.33

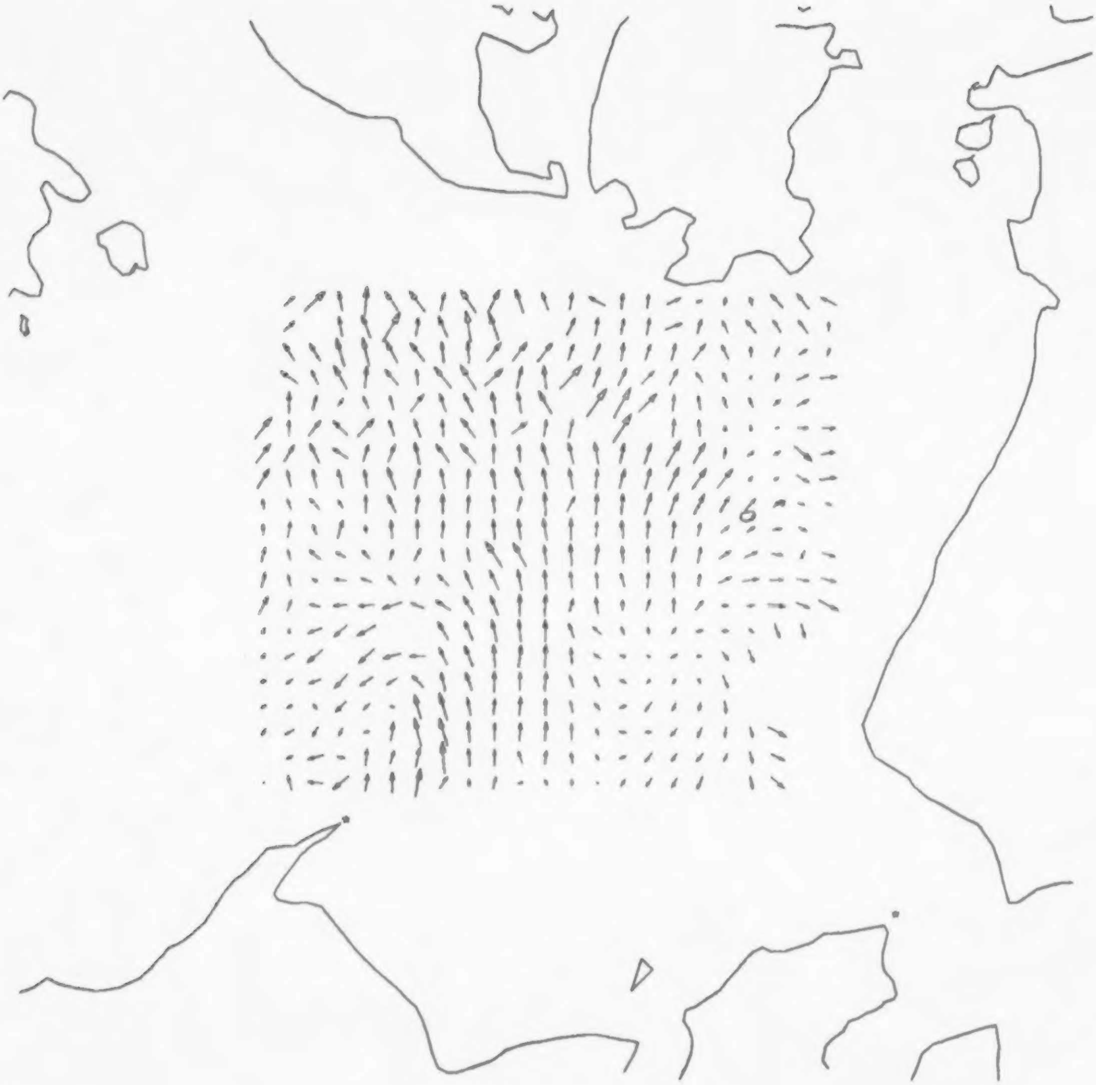


24 AUG 78 7: 0:00
DUNGENESS SPIT WASHINGTON
POINT WILSON WASH.

6 KM [――――――]
200 CM/S [――――――]

TRUE NORTH ↑

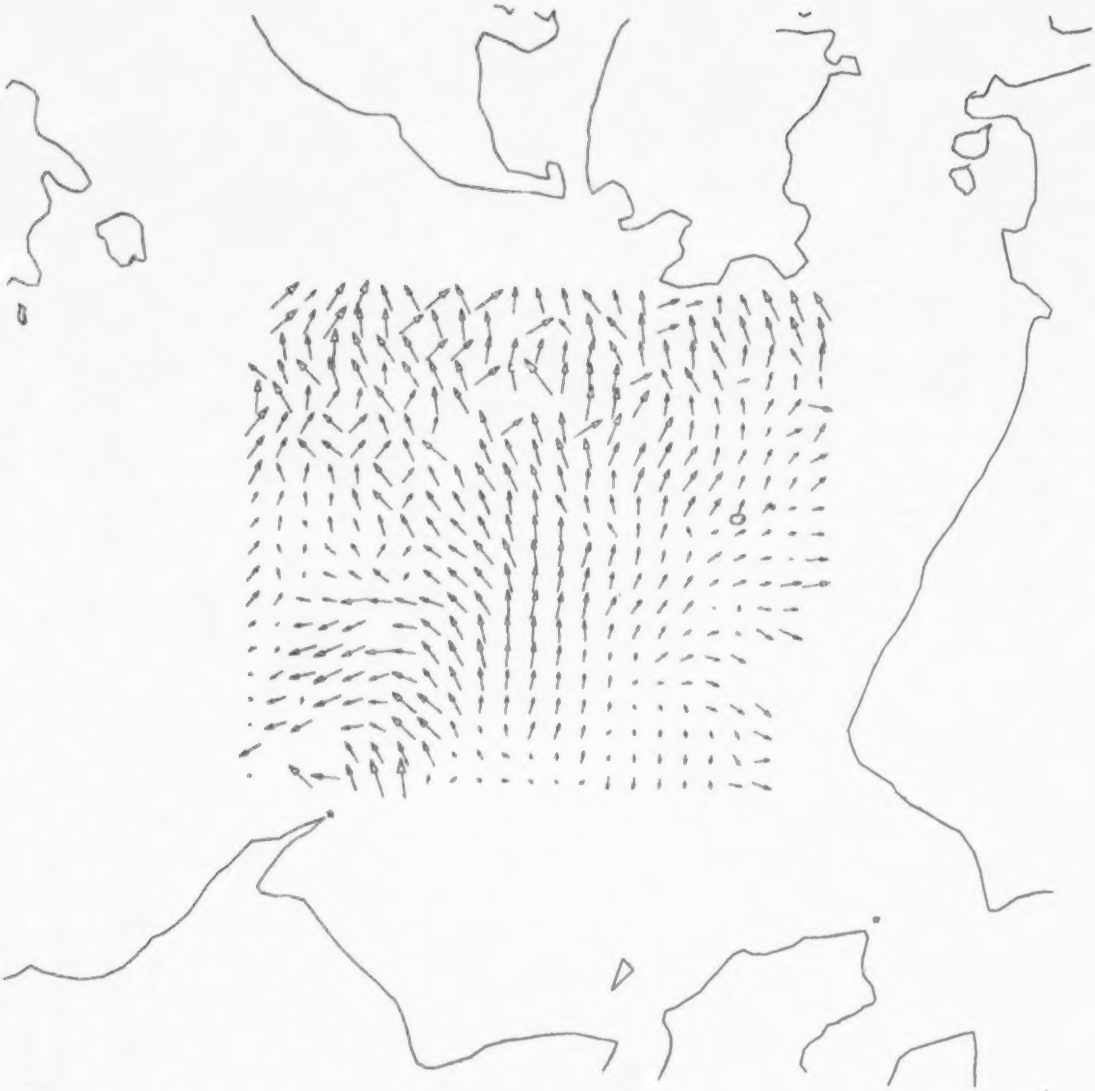
A 1.34



24 AUG 78   8: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

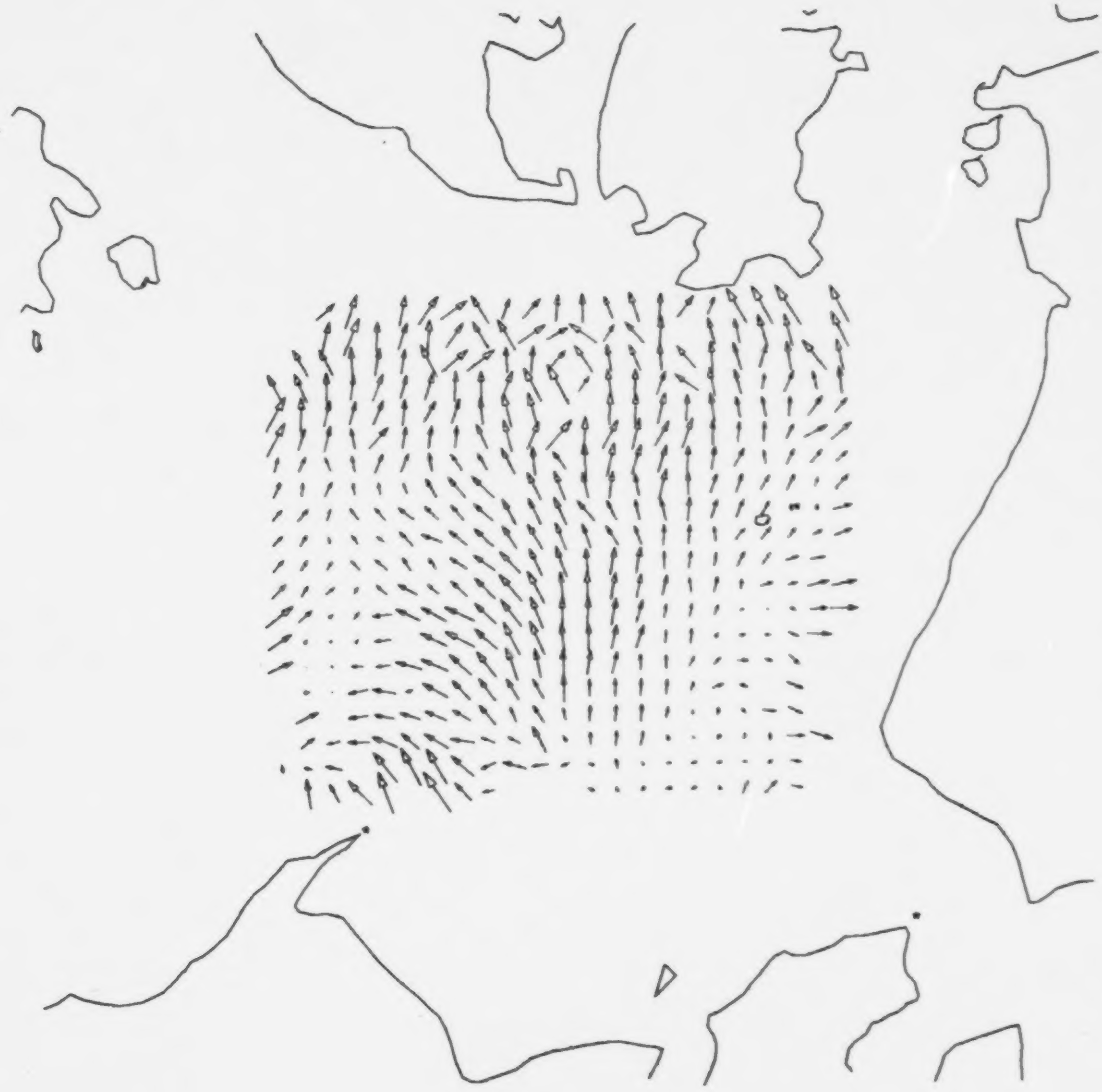
A 1.35



24 AUG 78 9: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [————————]
200 CM/S [————————]
TRUE NORTH ↑

A 1.36

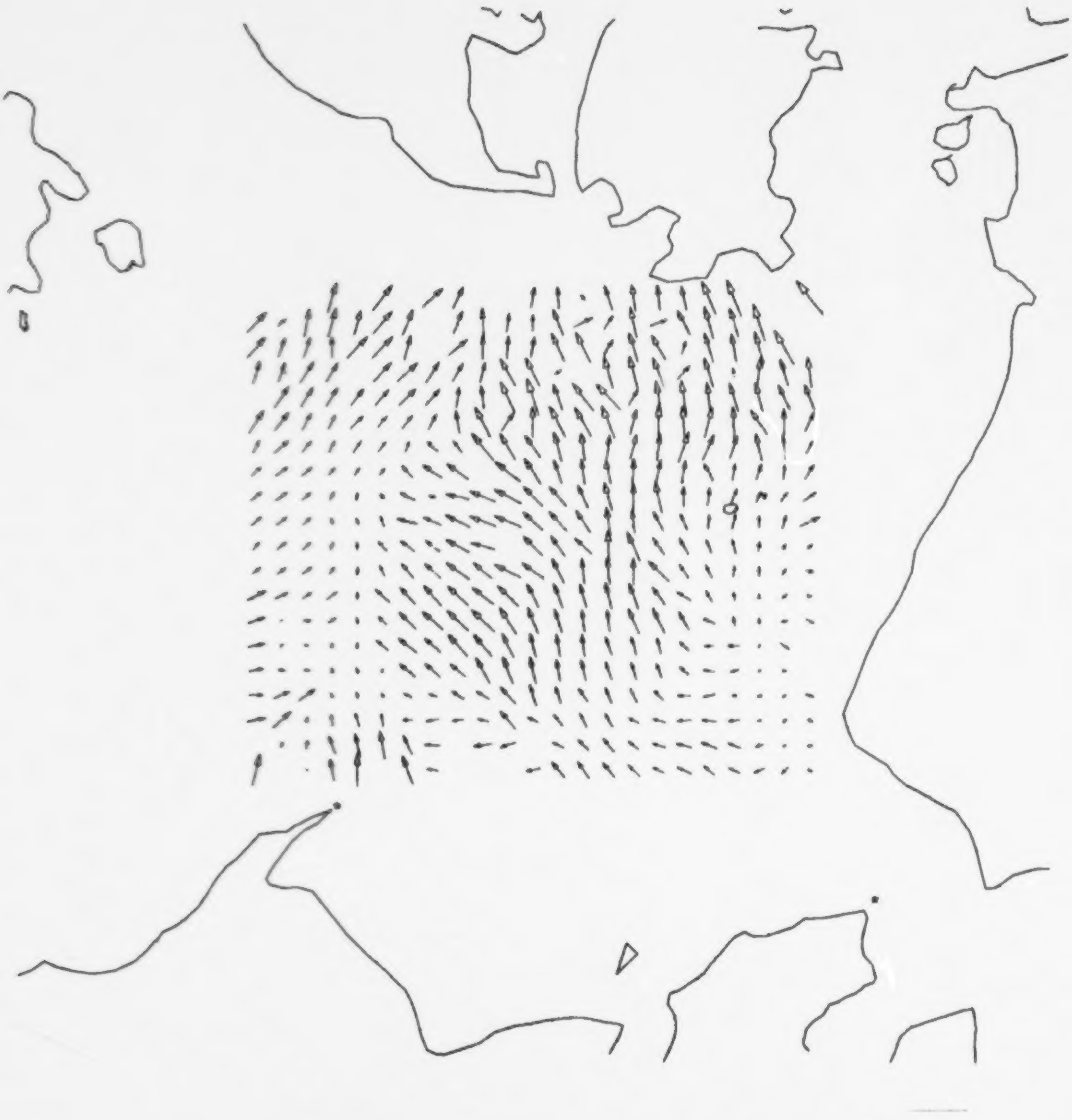


24 AUG 78 10: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

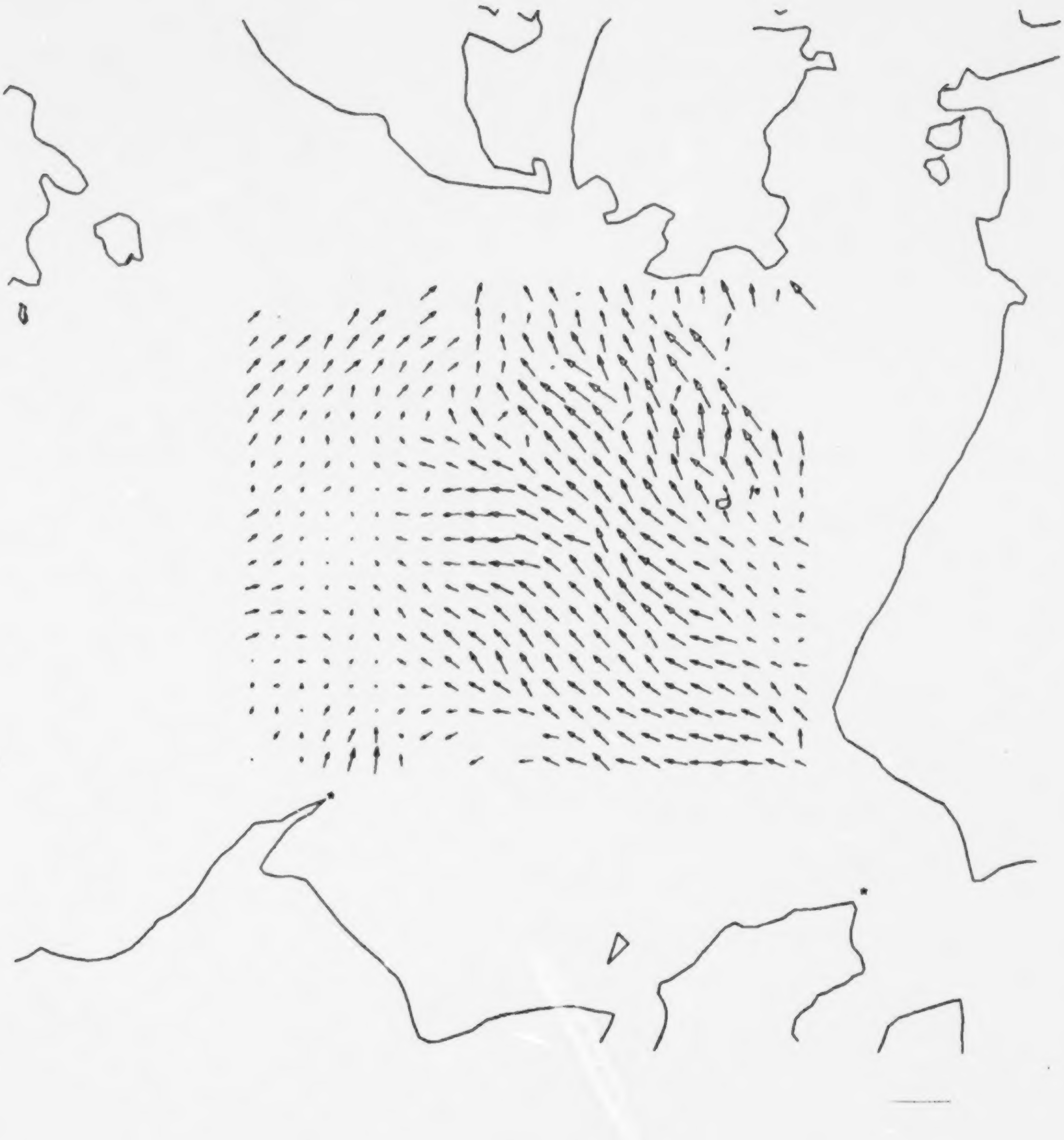
A 1.37



24 AUG 78 11: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.38

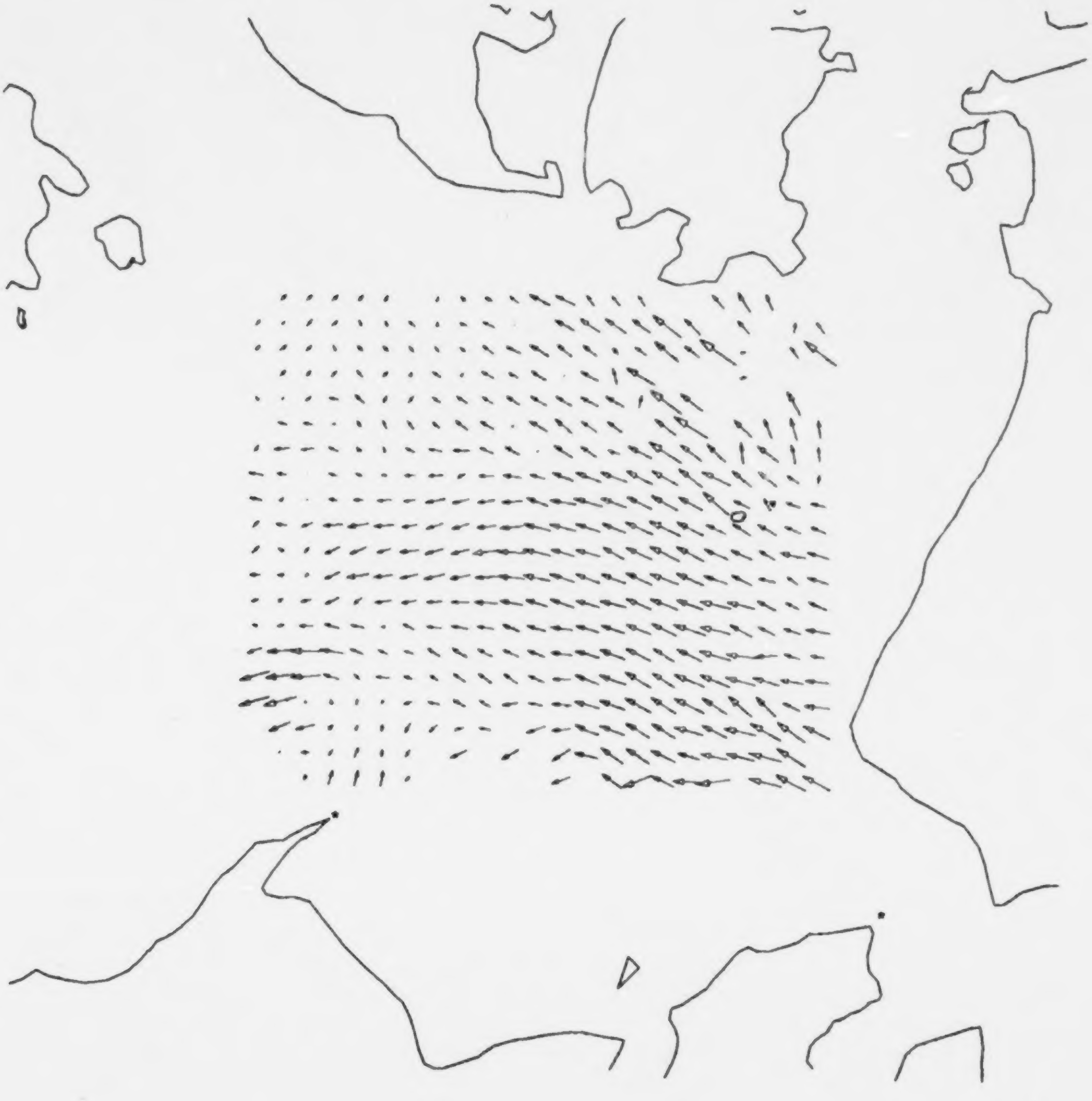


24 AUG 78 12: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

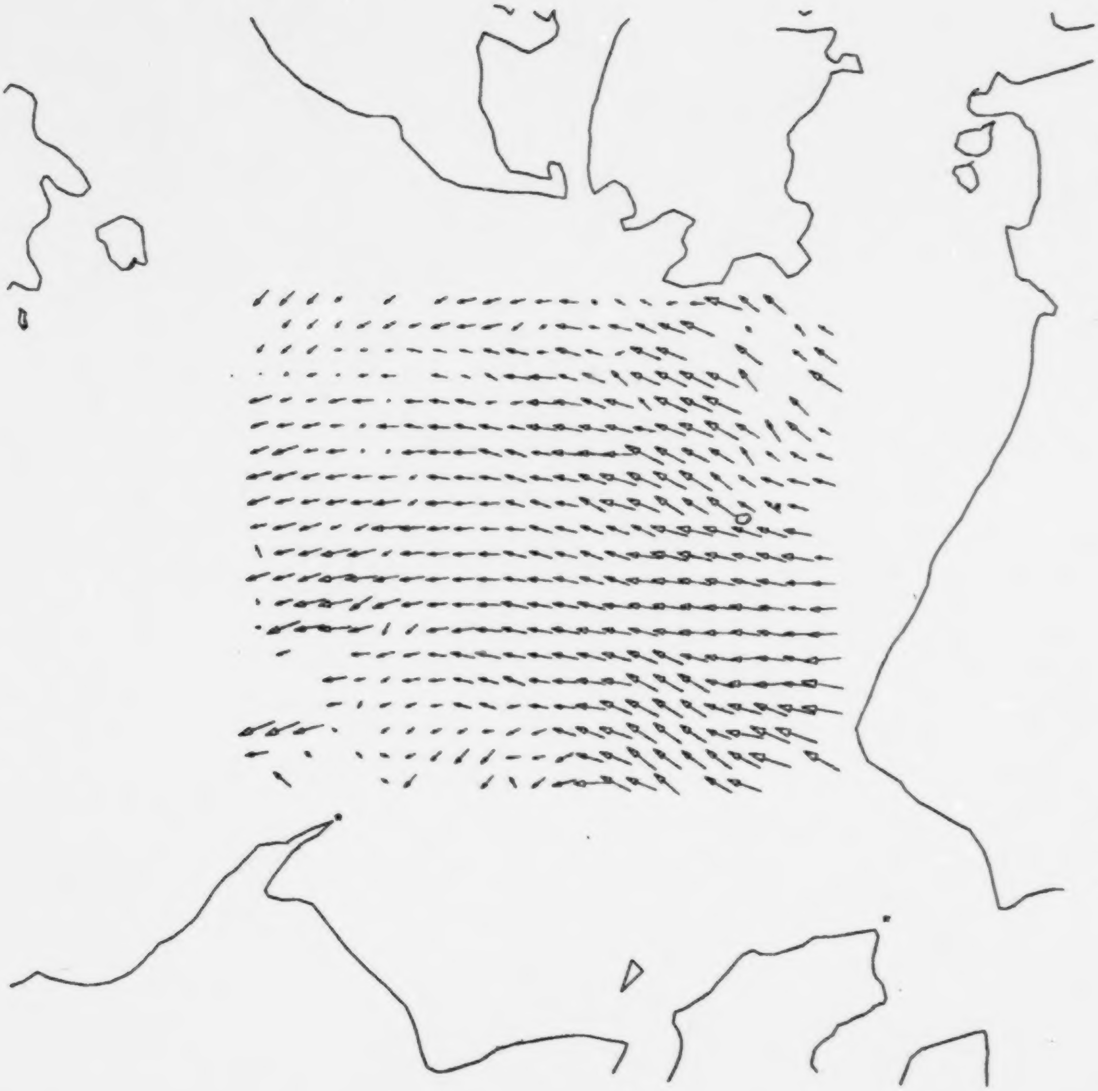
A 1.39



24 AUG 78 13: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

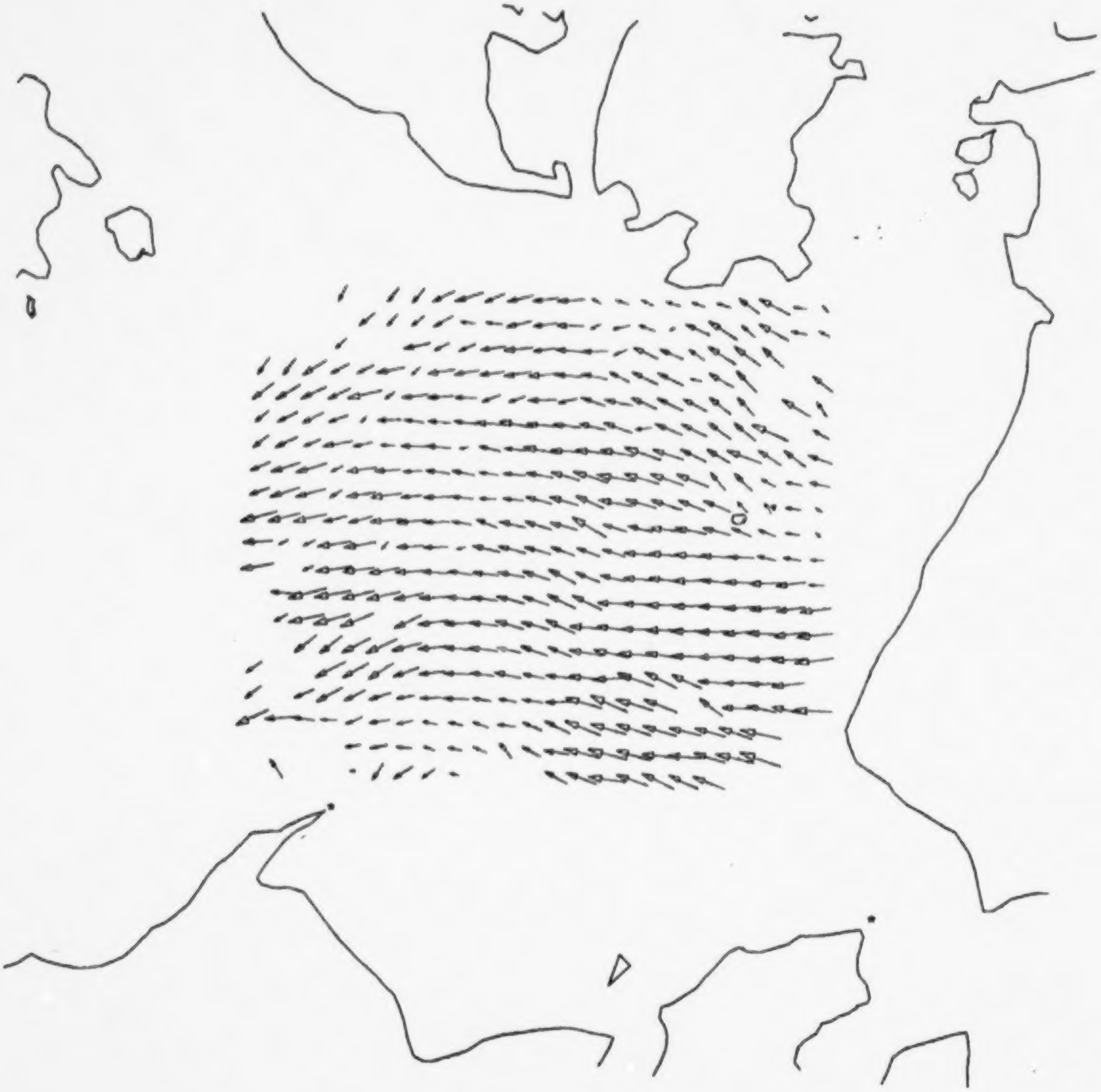
A 1.40



24 AUG 78 14: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [————]
200 CM/S [————]
TRUE NORTH ↑

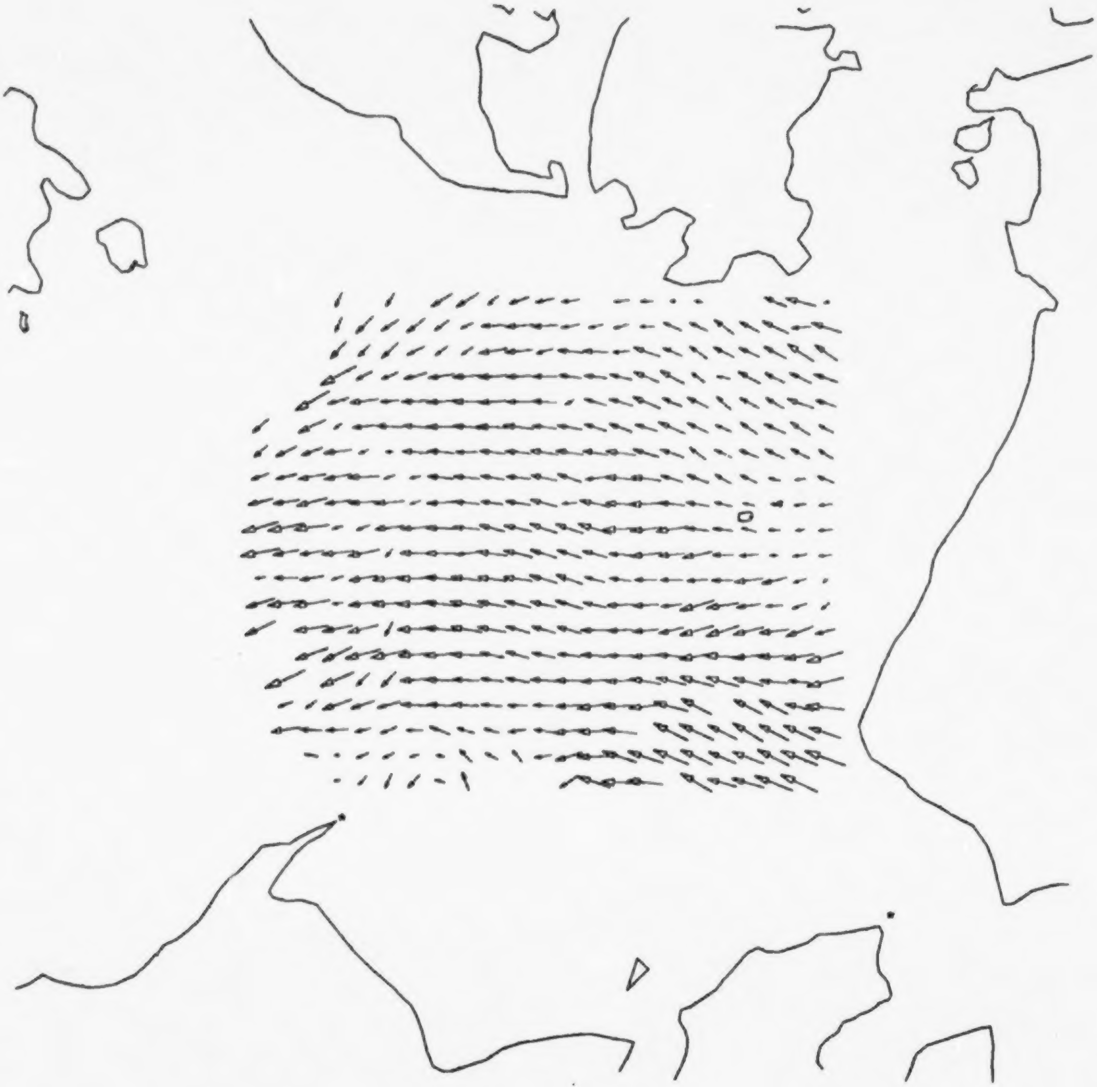
A 1.41



24 AUG 78 15: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

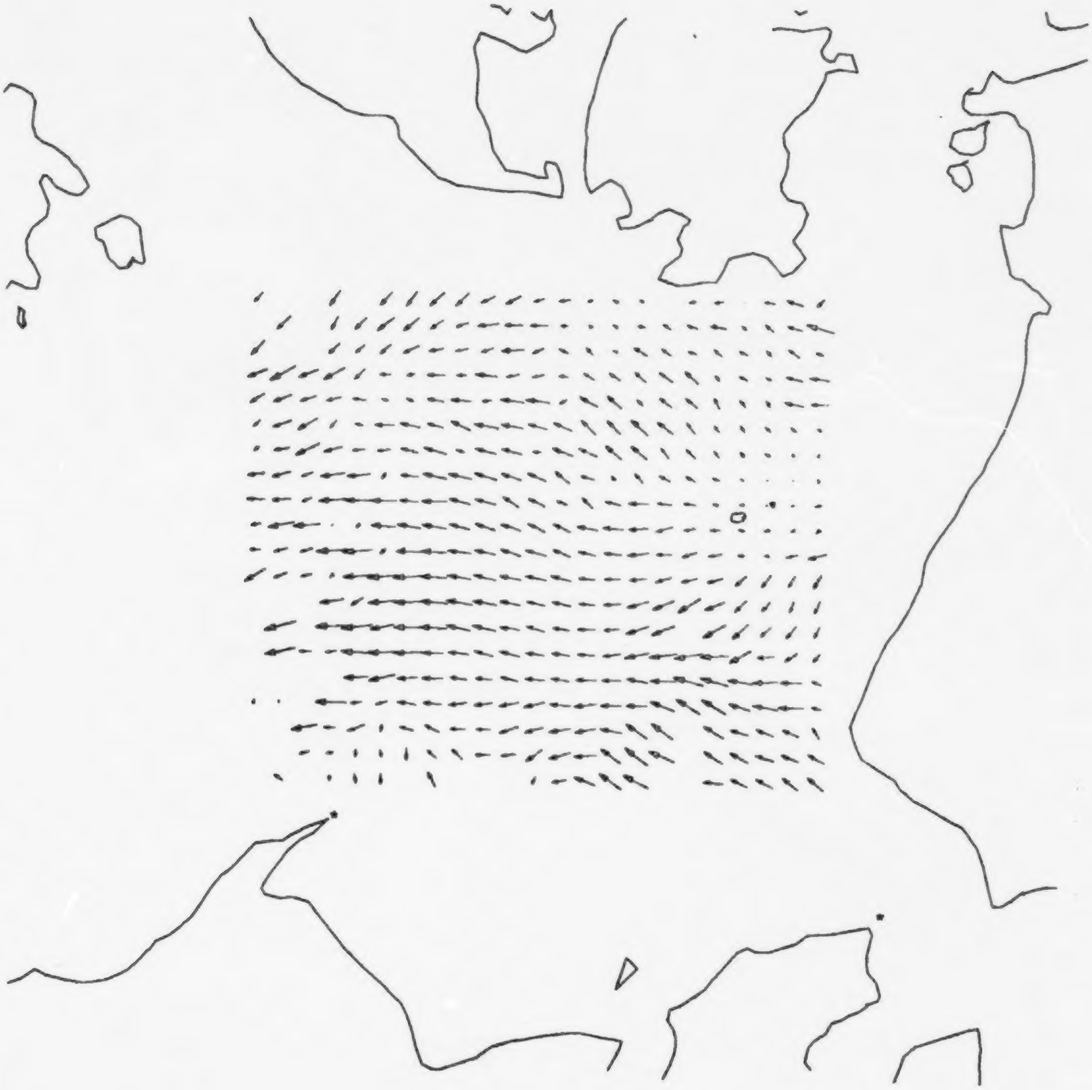
A 1.42



24 AUG 78 16: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [———————]
200 CM/S [———————]
TRUE NORTH ↑

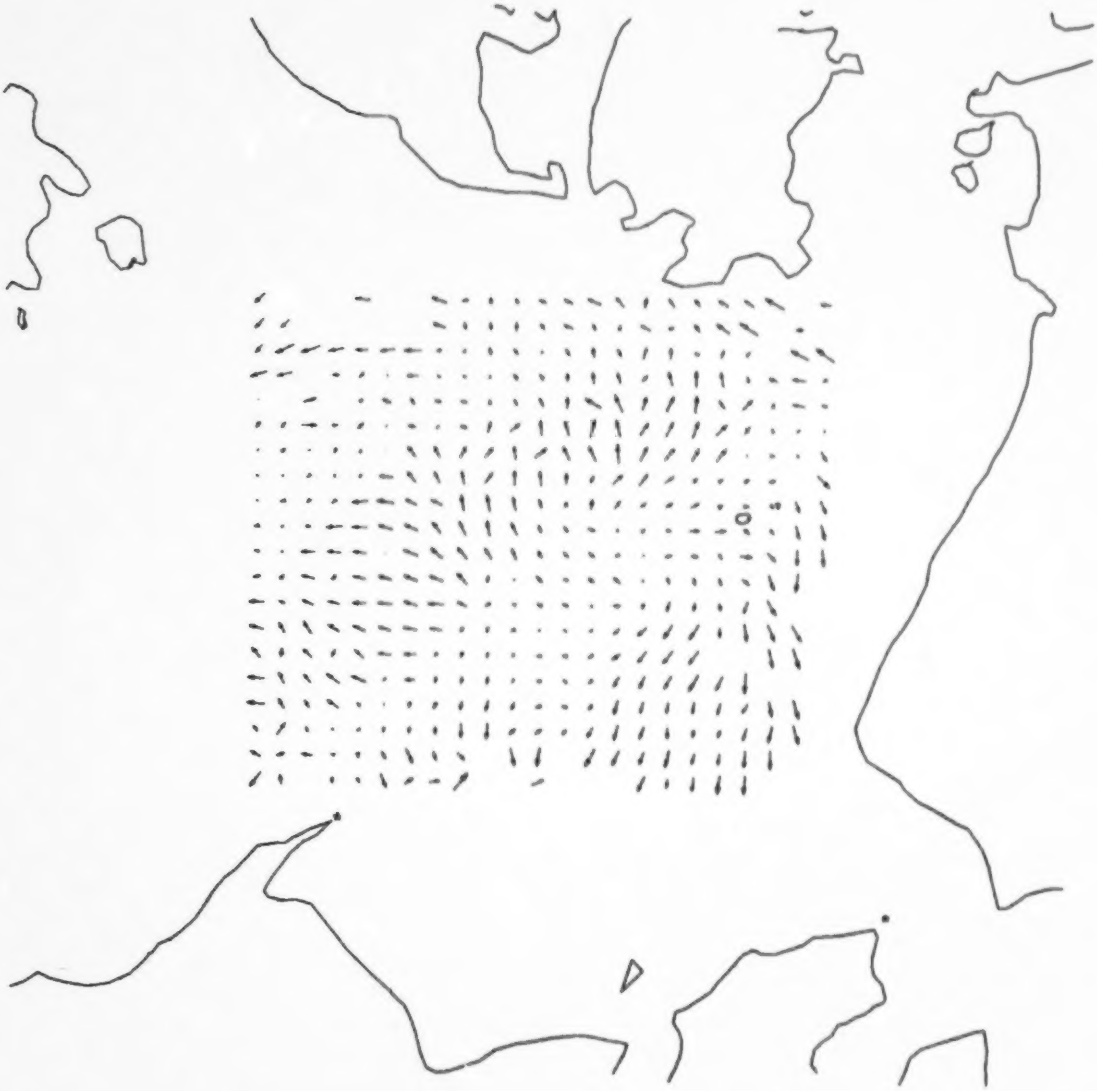
A 1.43



24 AUG 78 17: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [—————]
200 CM/S [—————]
TRUE NORTH ↑

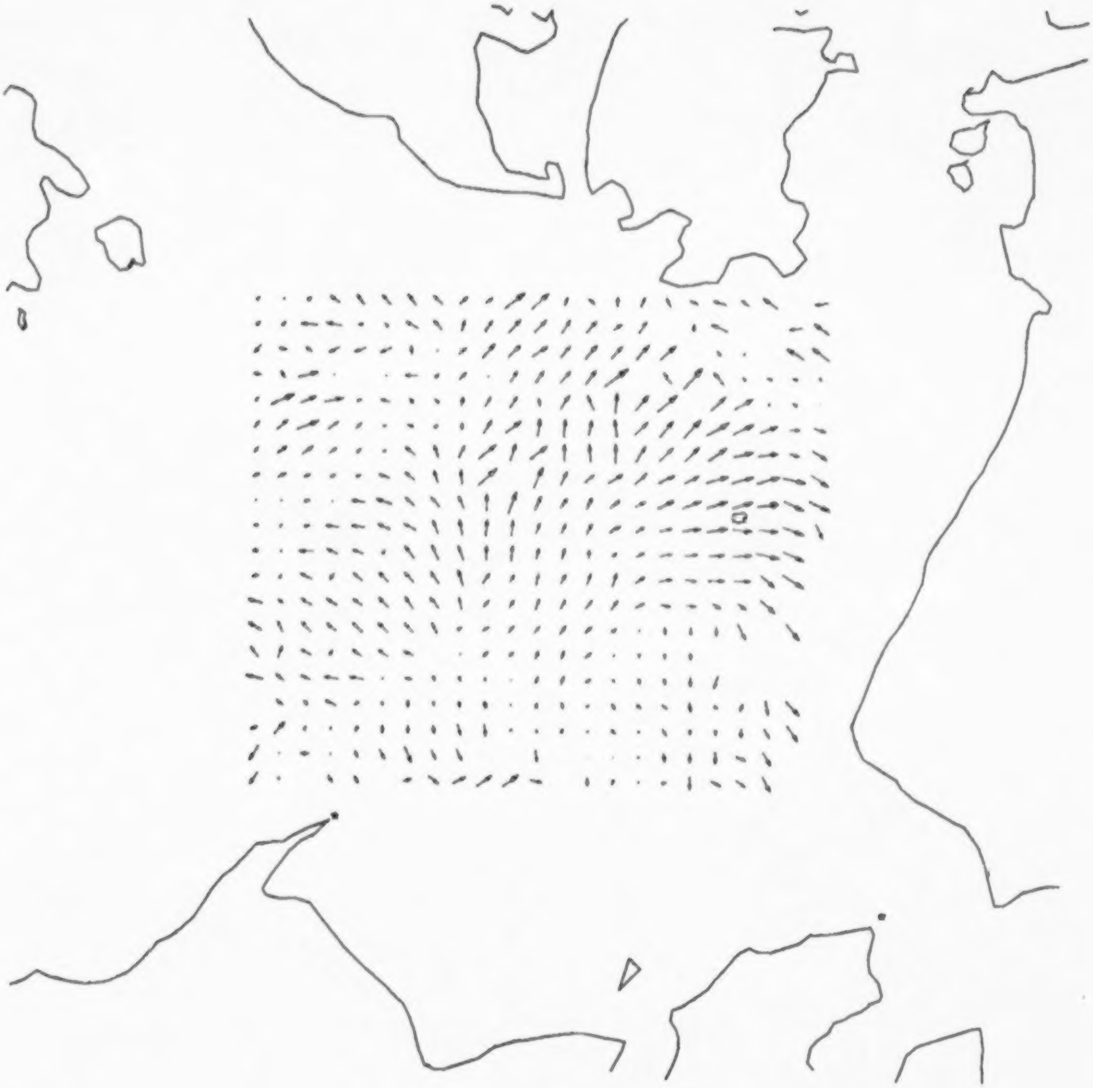
A 1.44



24 AUG 78 18: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

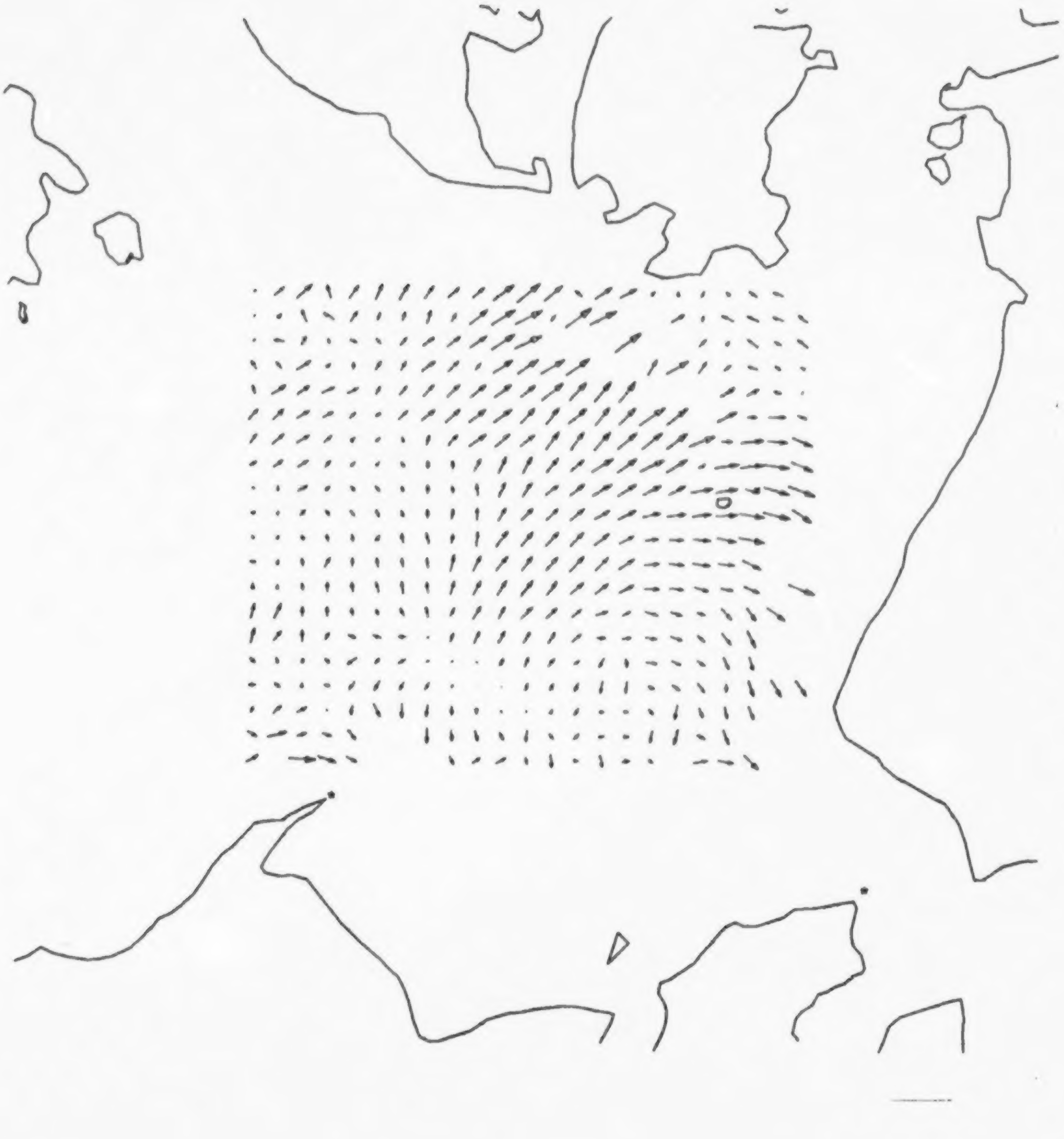
A 1.45



24 AUG 78 19: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.46

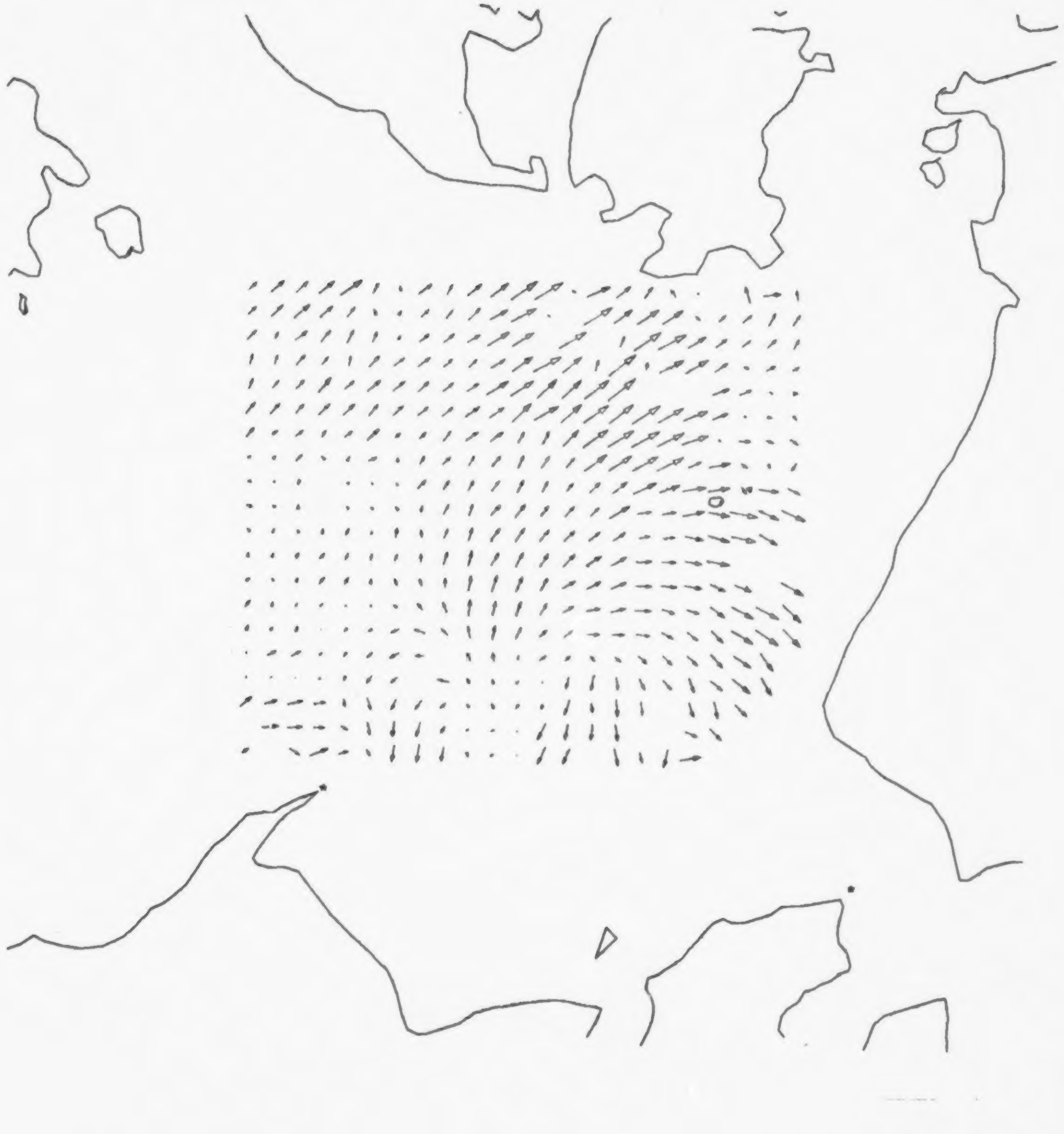


24 AUG 78 20: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

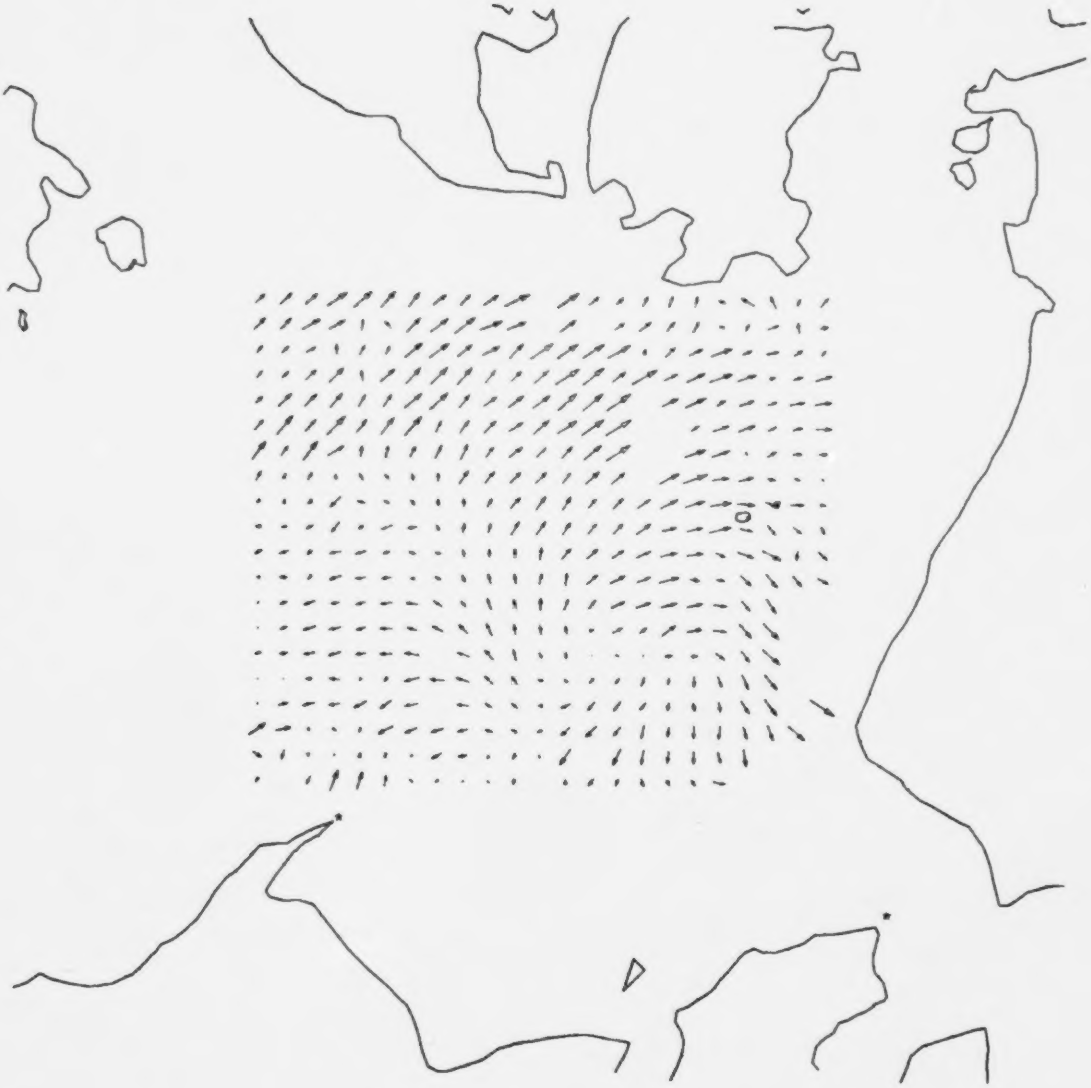
A 1.47



24 AUG 78 21: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

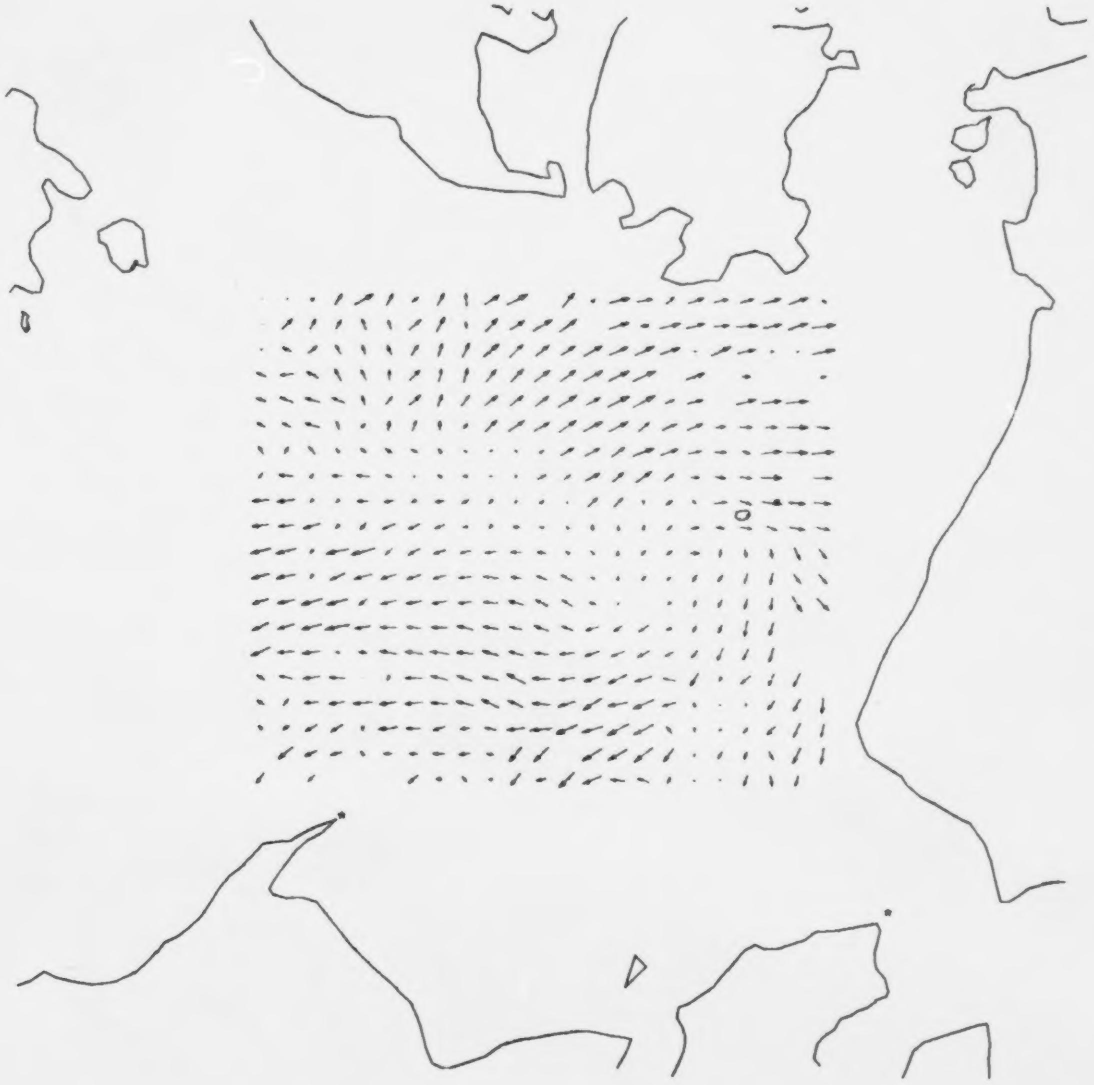
A 1.4R



24 AUG 78 22: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

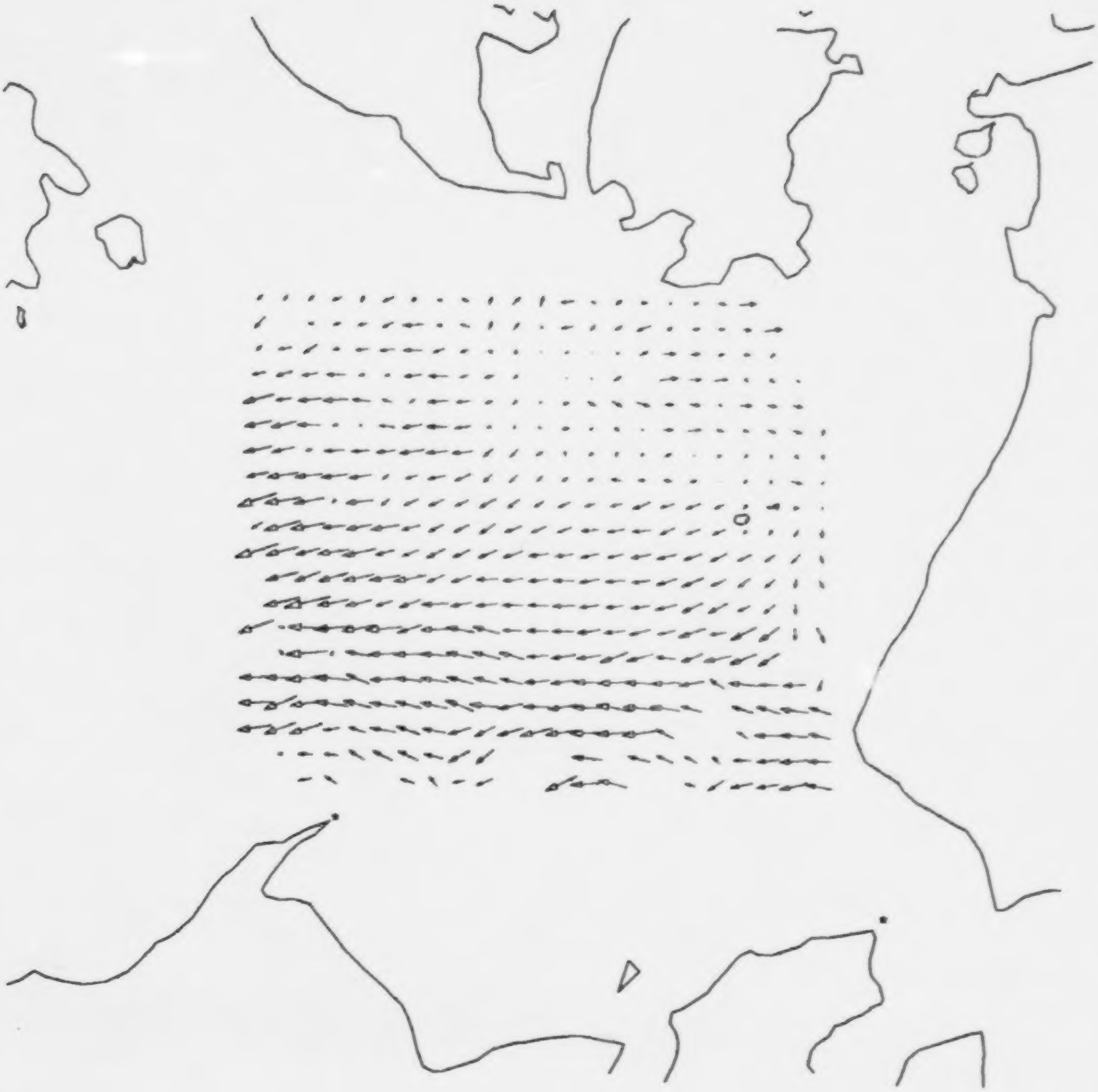
A 1.49



24 AUG 78 23: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.50

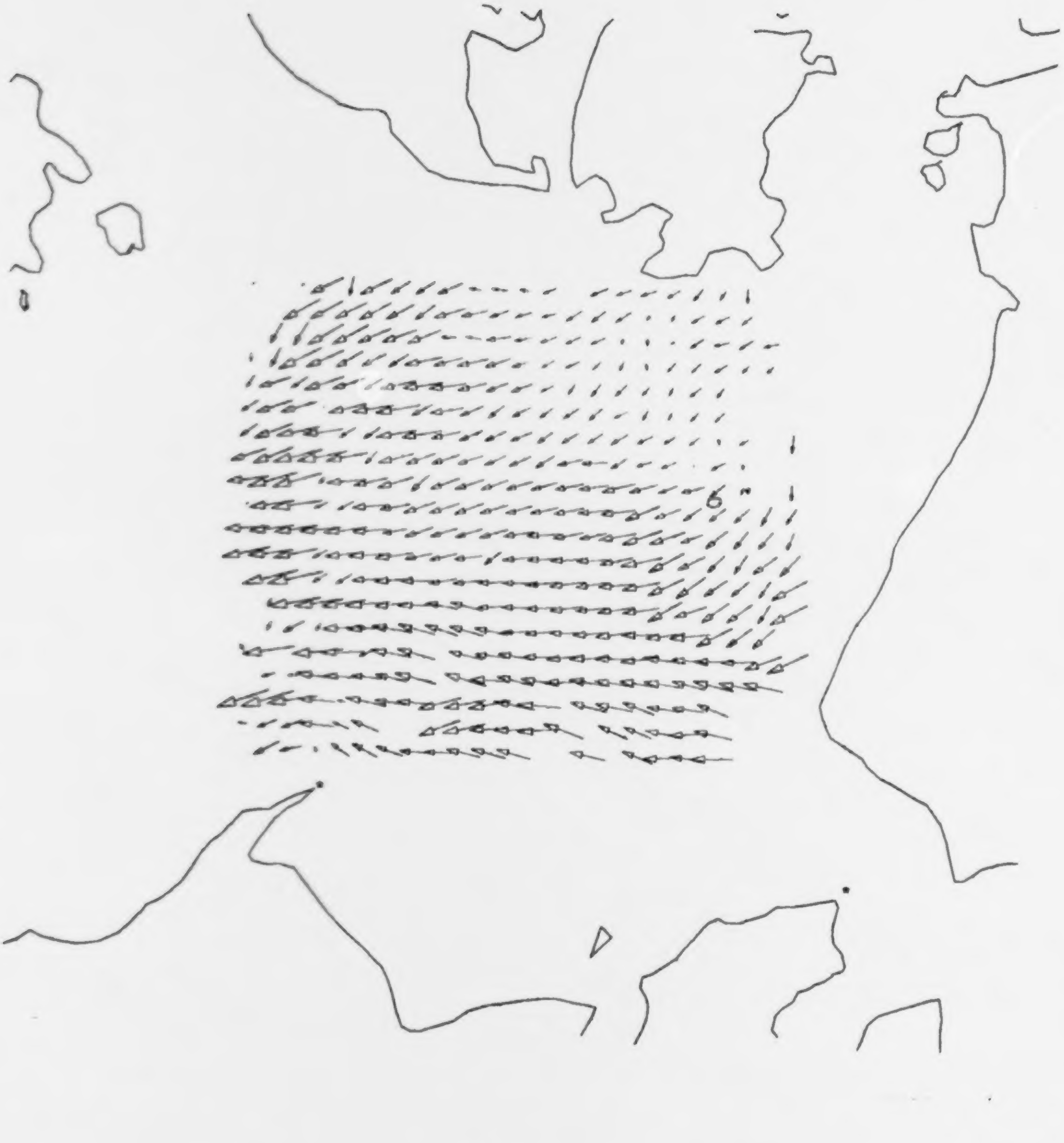


25 AUG 78 0: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

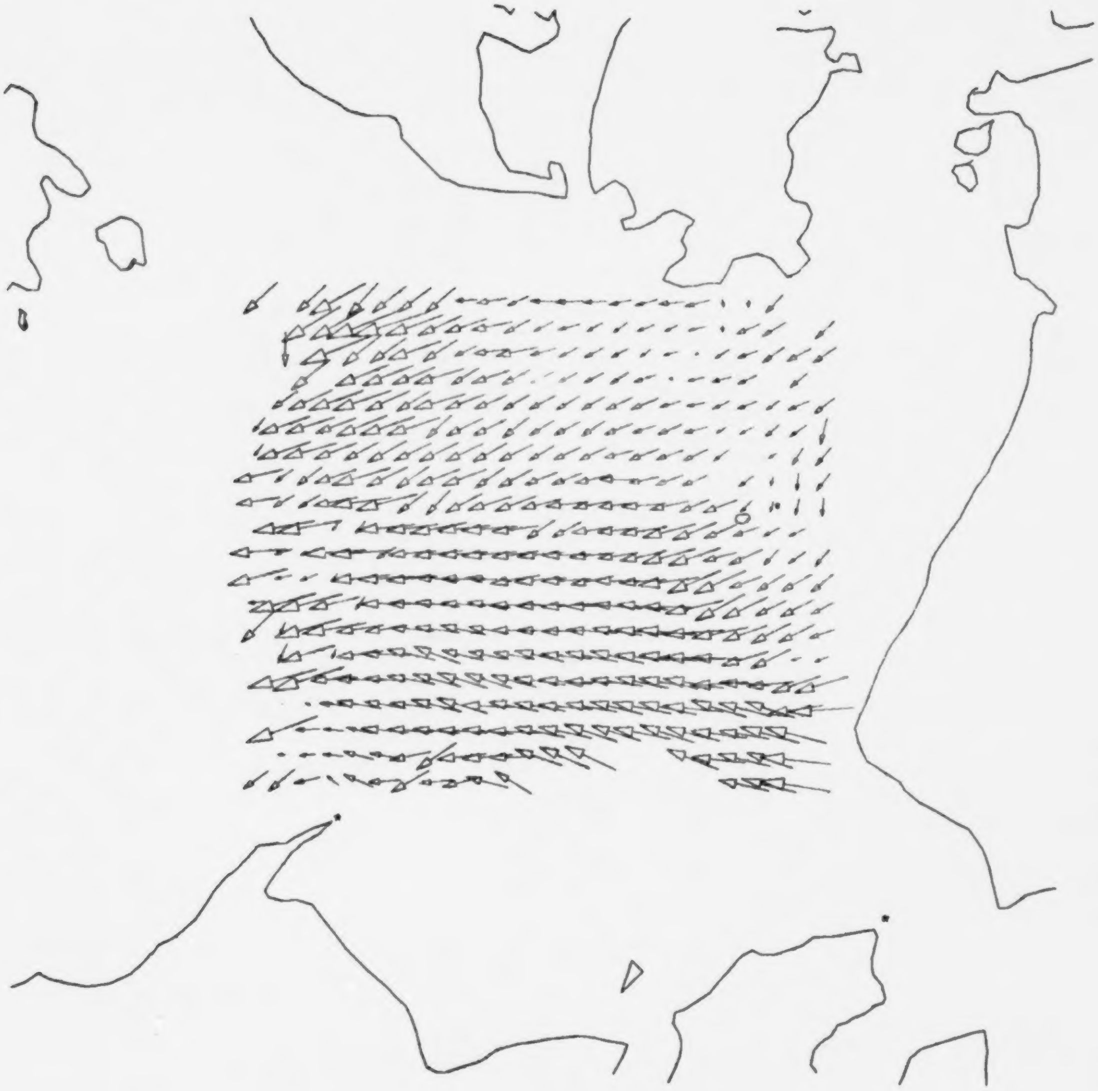
A 1.51



25 AUG 78   1: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [------------]
200 CM/S [------------]
TRUE NORTH ↑

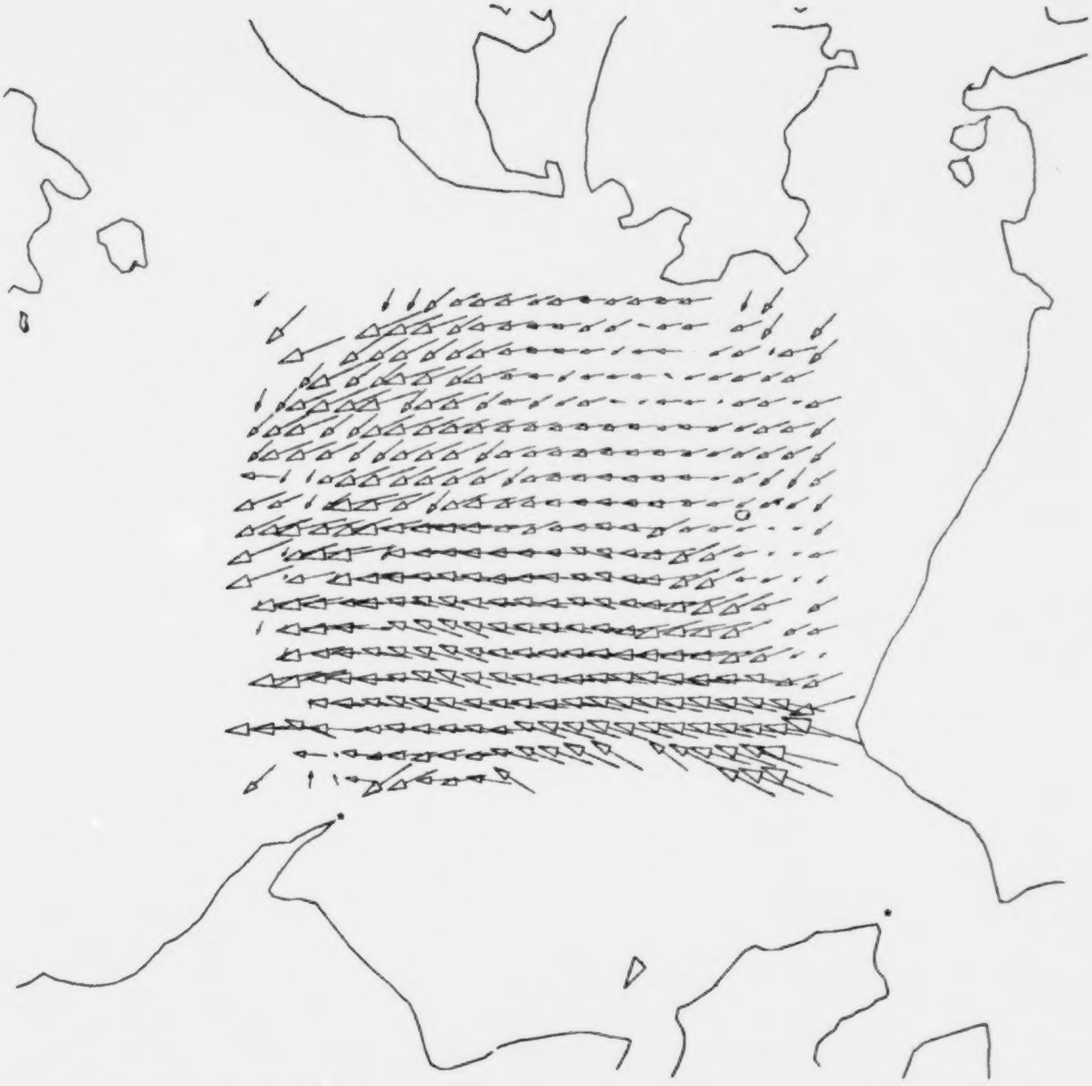
A 1.52



25 AUG 78   2: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 Q'/S [——————]
TRUE NORTH ↑

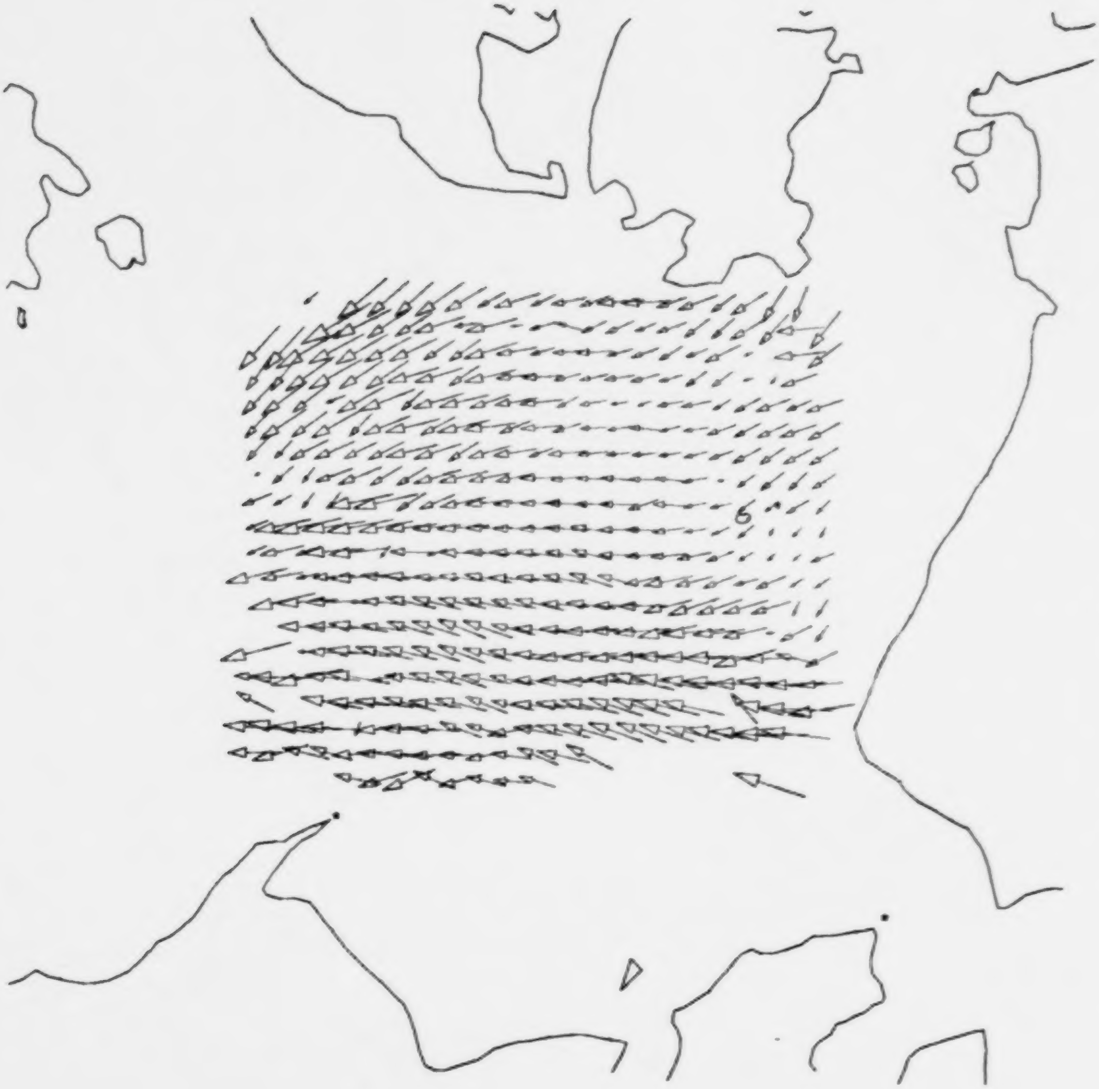
A 1.53



25 AUG 78 3: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [---------------]
200 CM/S [---------------]
TRUE NORTH ↑

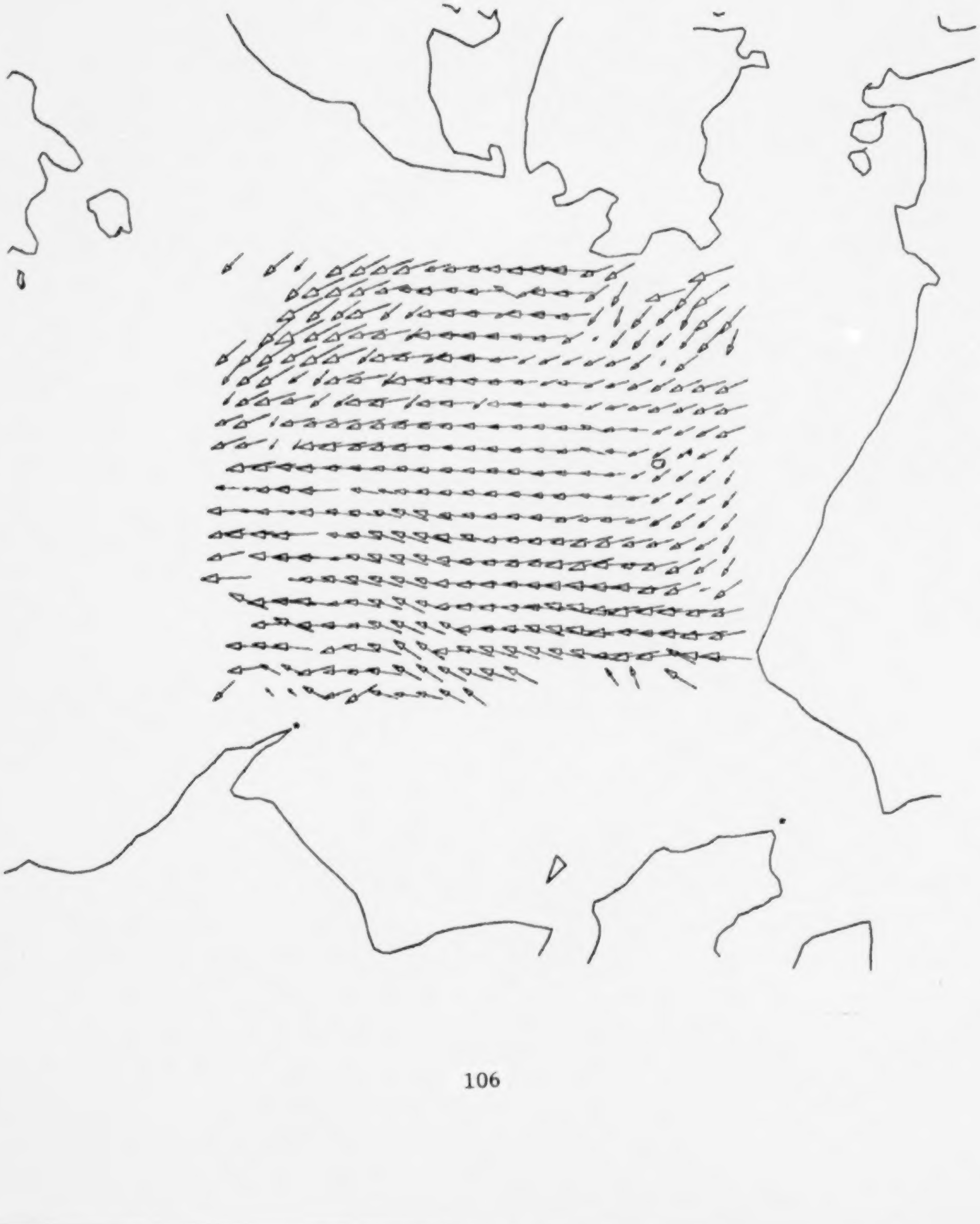
A 1.54



25 AUG 78 4: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [---------------]
200 CM/S [-----------------]
TRUE NORTH ↑

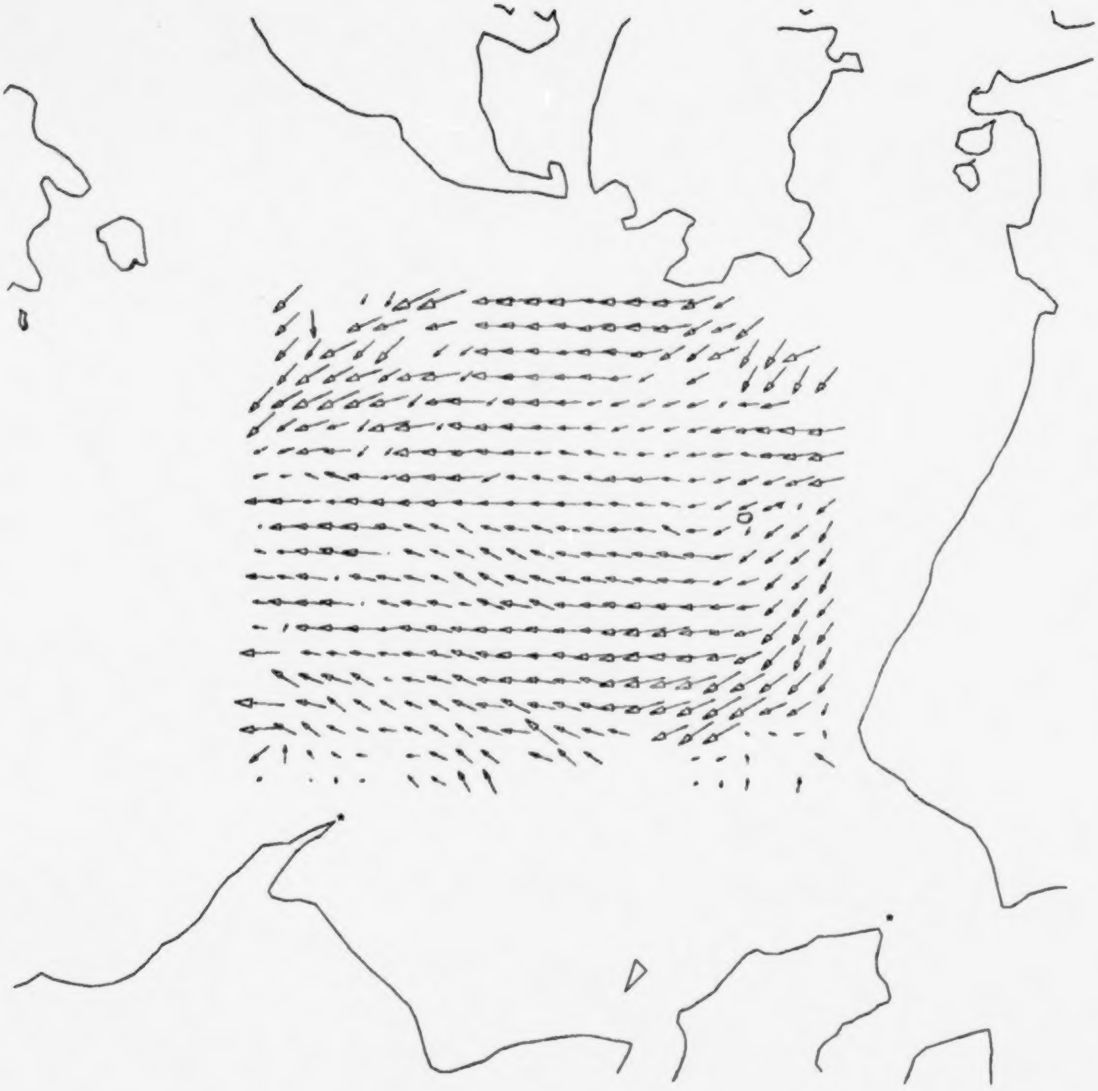
A 1.55



25 AUG 78 5: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [————]
200 CM/S [————]
TRUE NORTH ↑

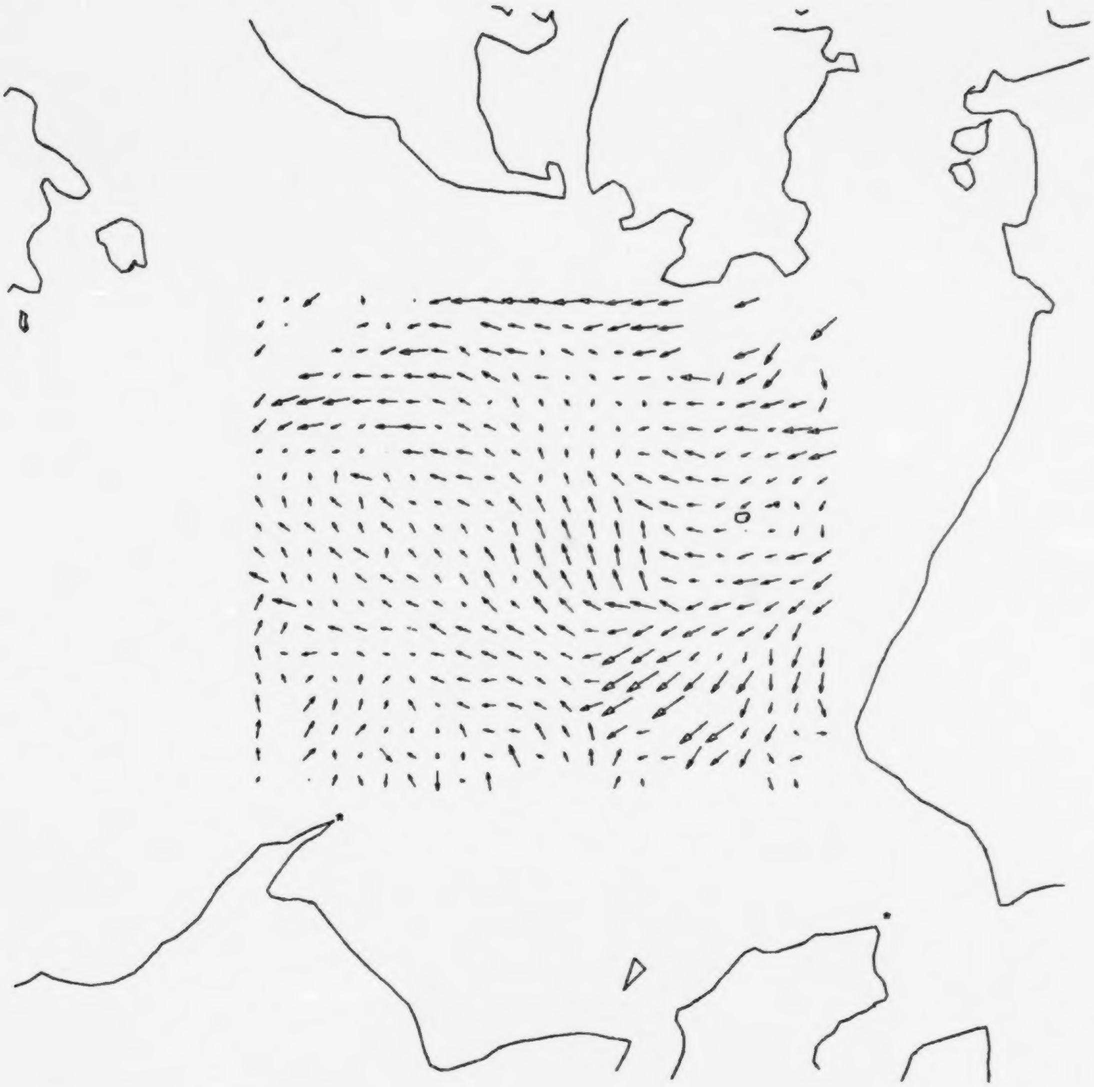
A 1.56



25 AUG 78   6: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

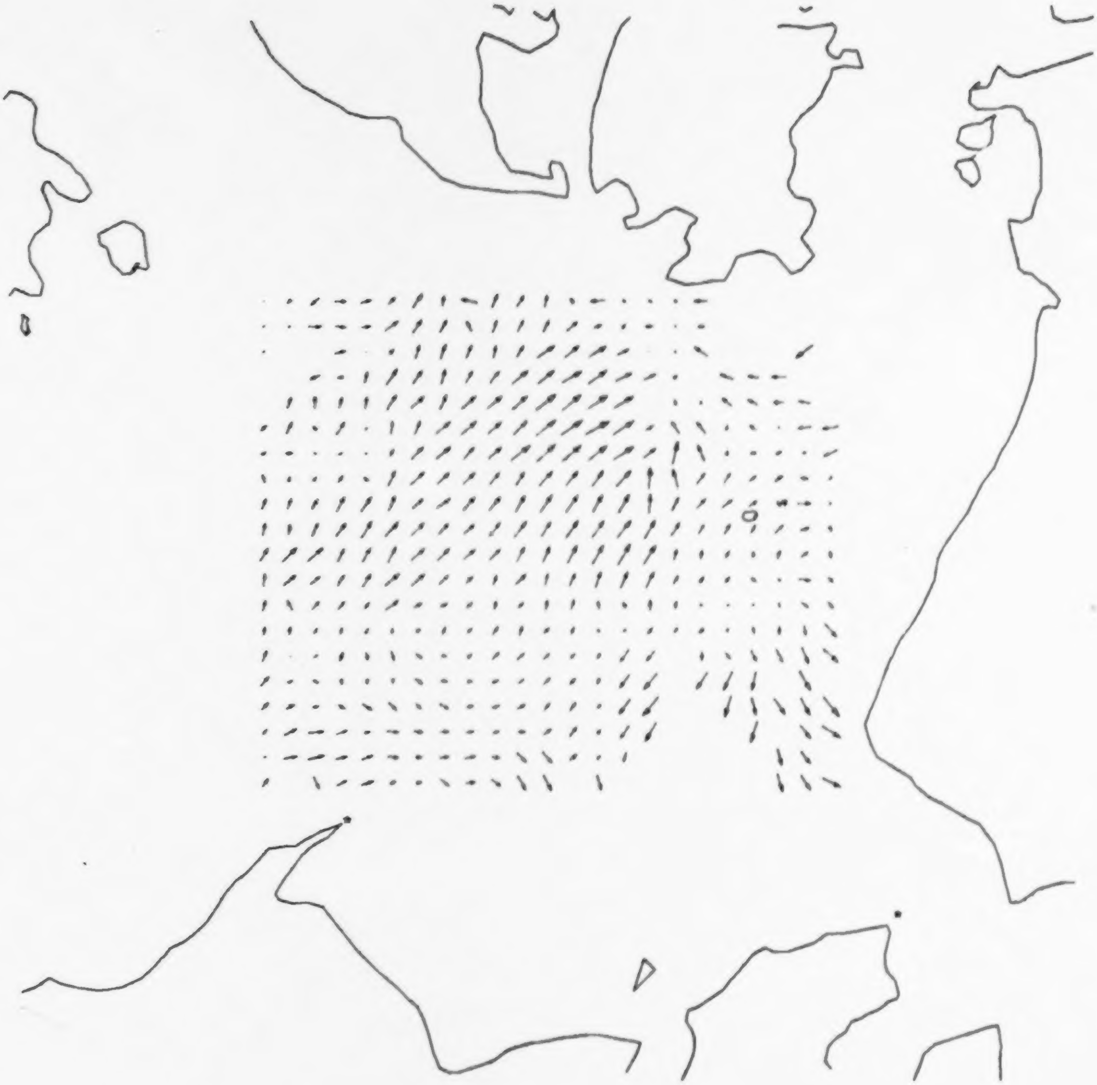
6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.57



25 AUG 78   7: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

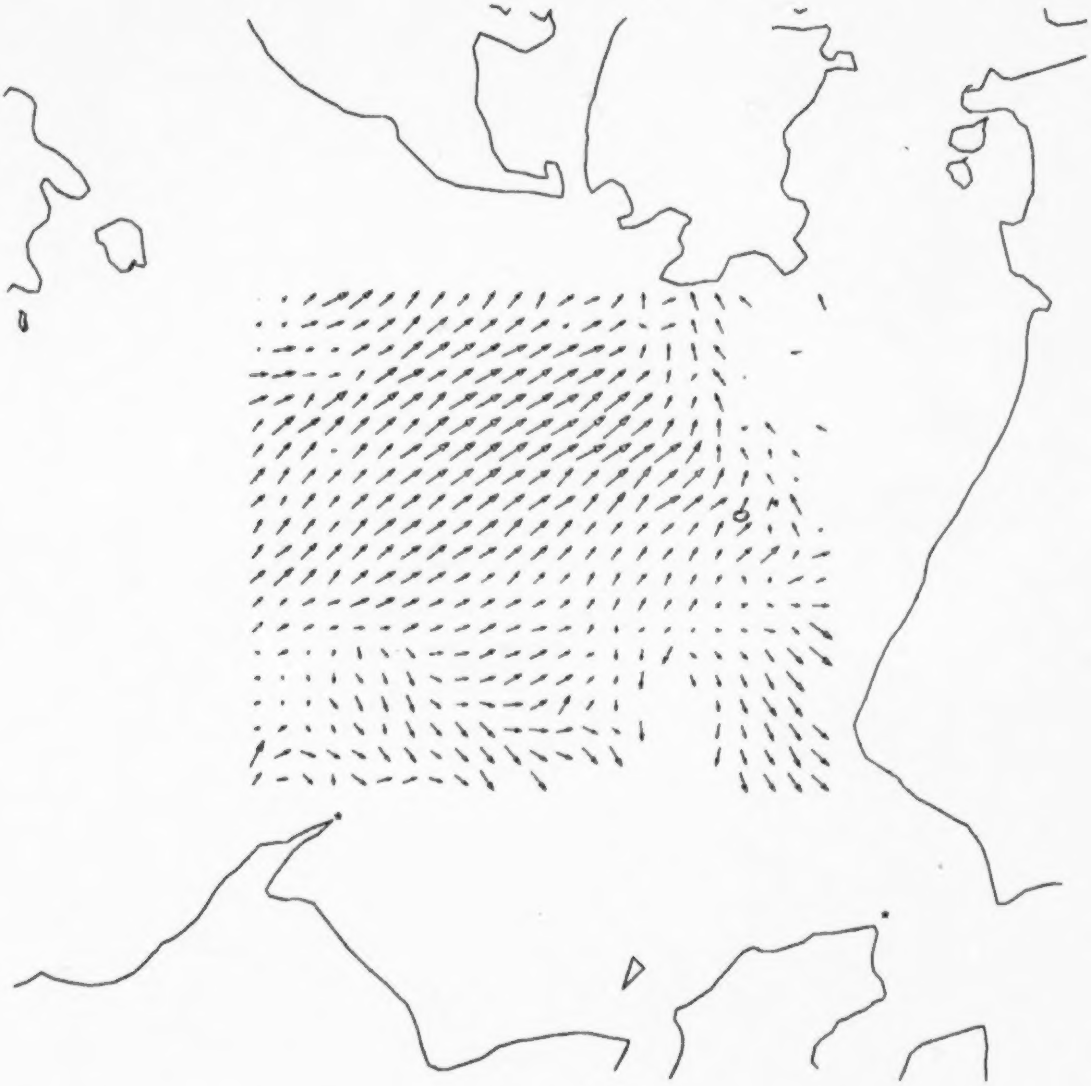
A 1.53


6 KM
200 CM/S
TRUE NORTH ↑

25 AUG 78   8: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

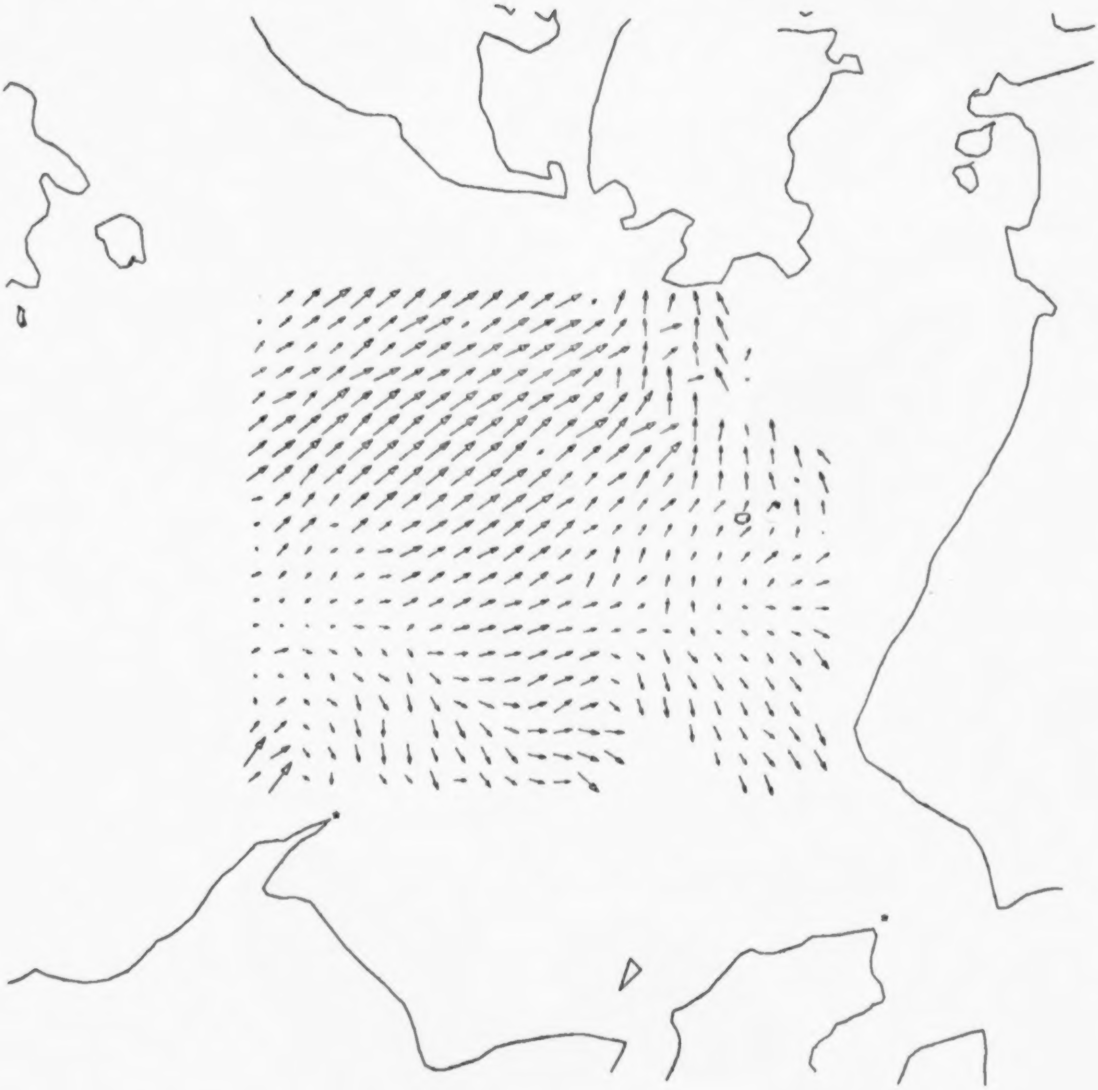
A 1.59



25 AUG 78 9: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

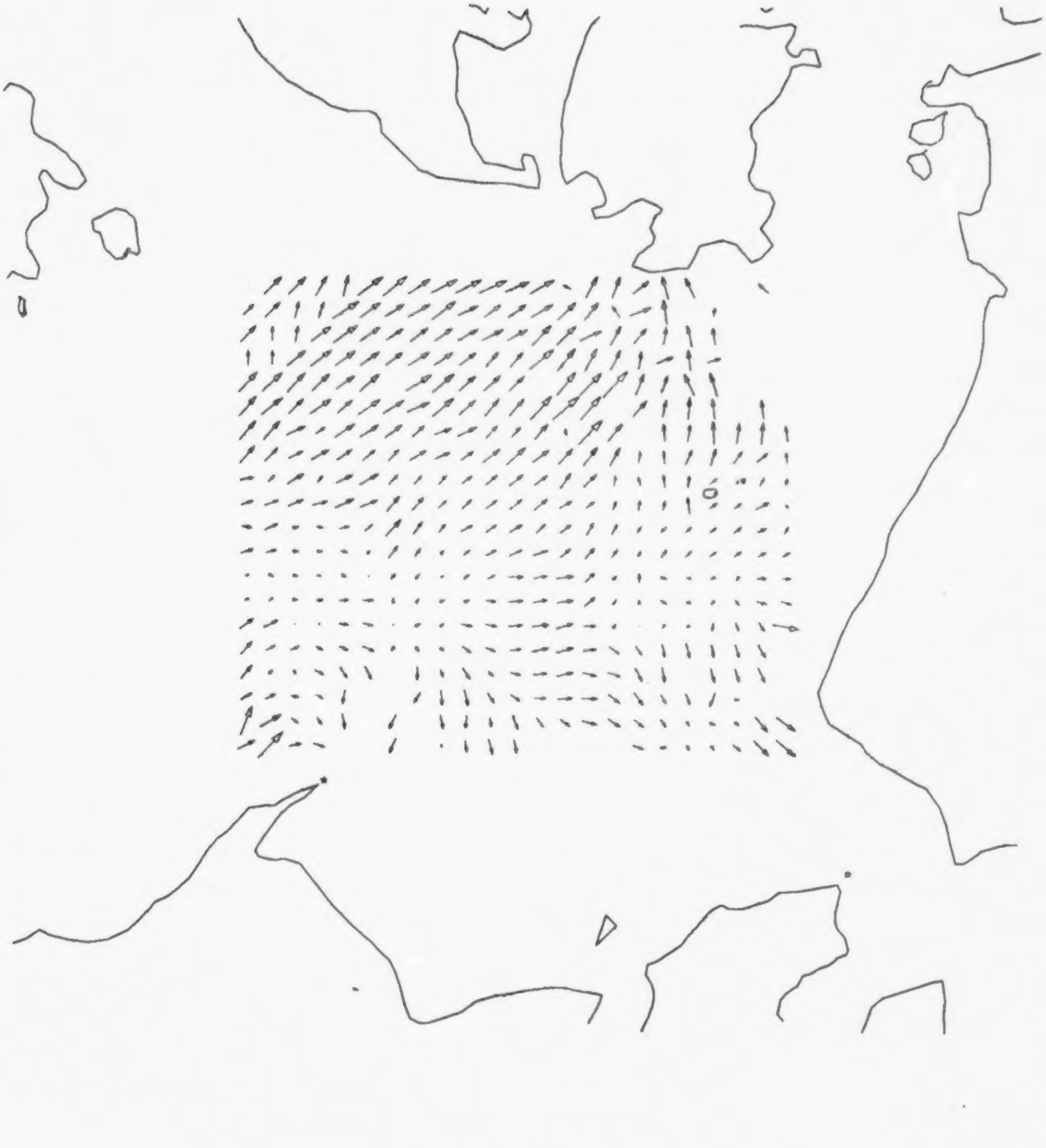
A 1.60



25 AUG 78 10: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 1.61

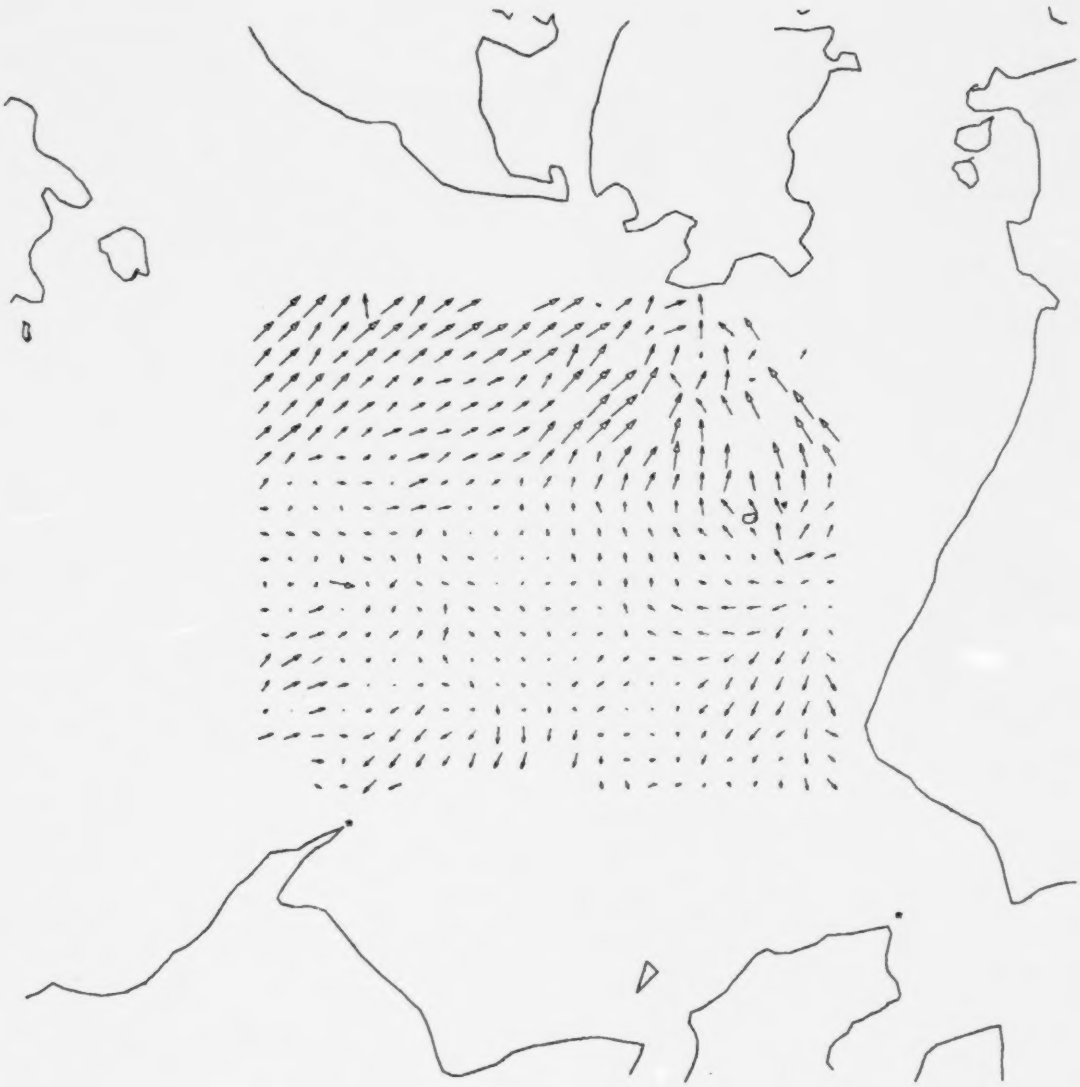


25 AUG 78 11: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 1.62

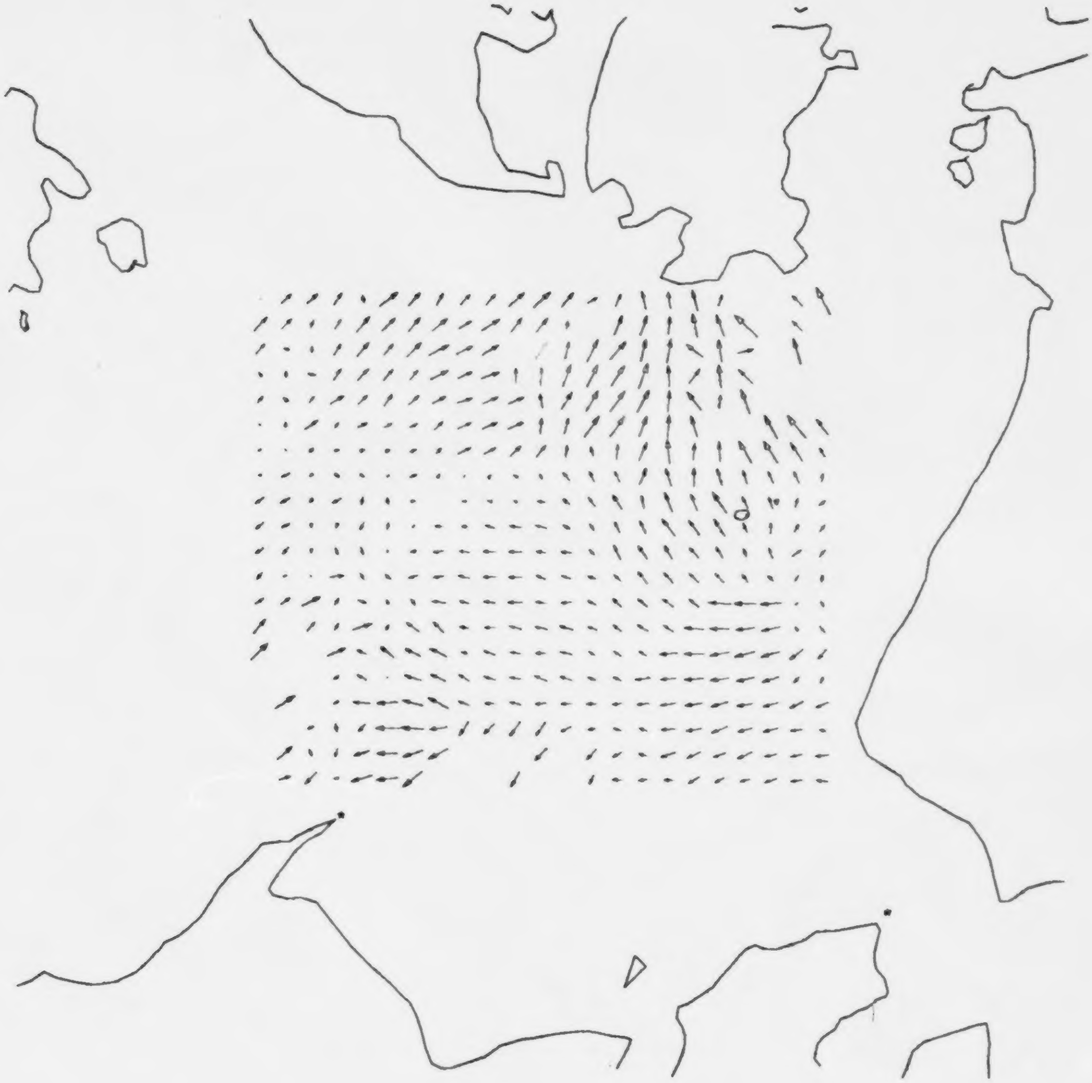


25 AUG 78 12: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASHIN

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 1.63

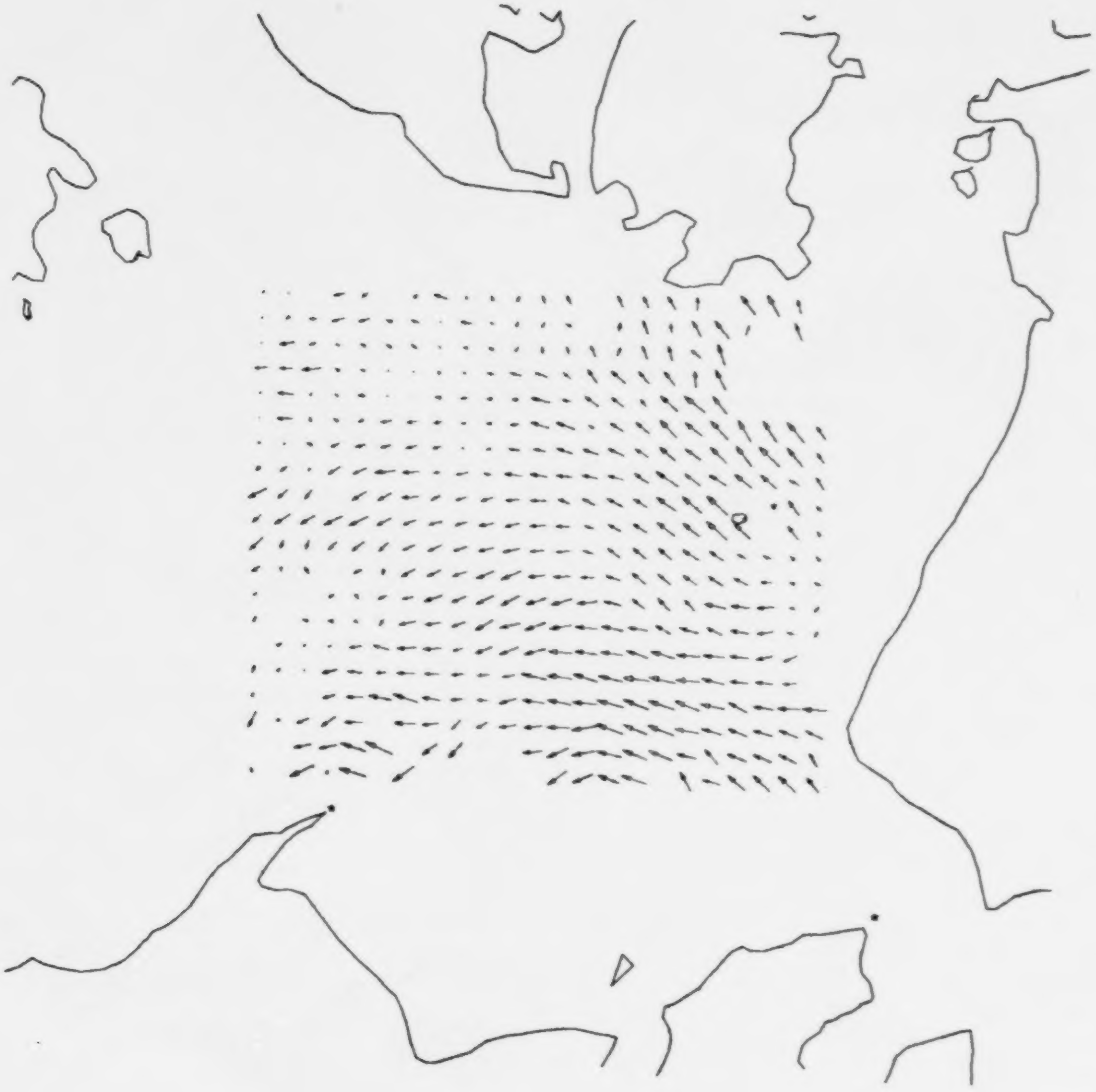


25 AUG 78 13: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 1.64

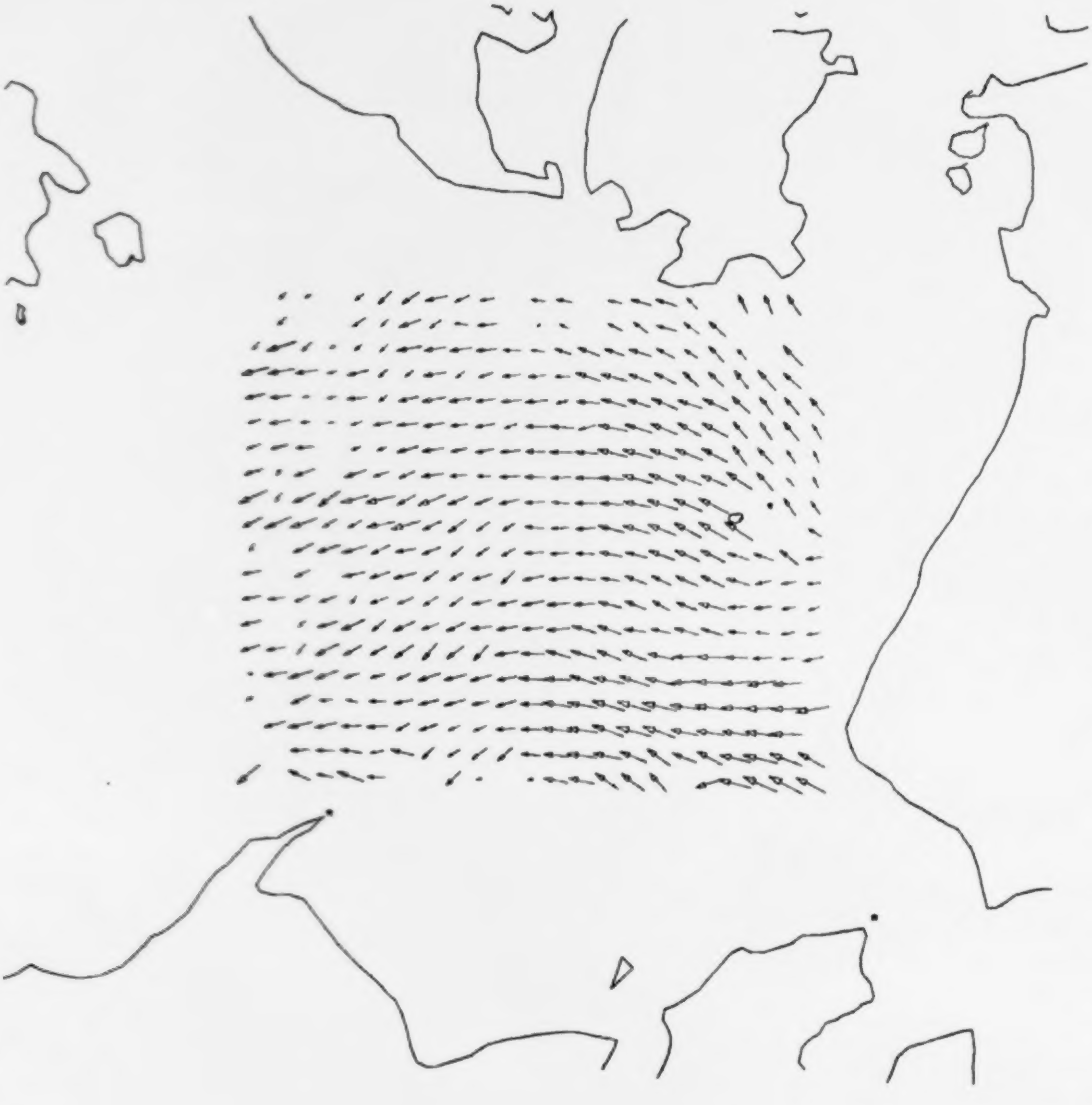


25 AUG 78 14: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [————————]
200 CM/S [————————]

TRUE NORTH ↑

A 1.65

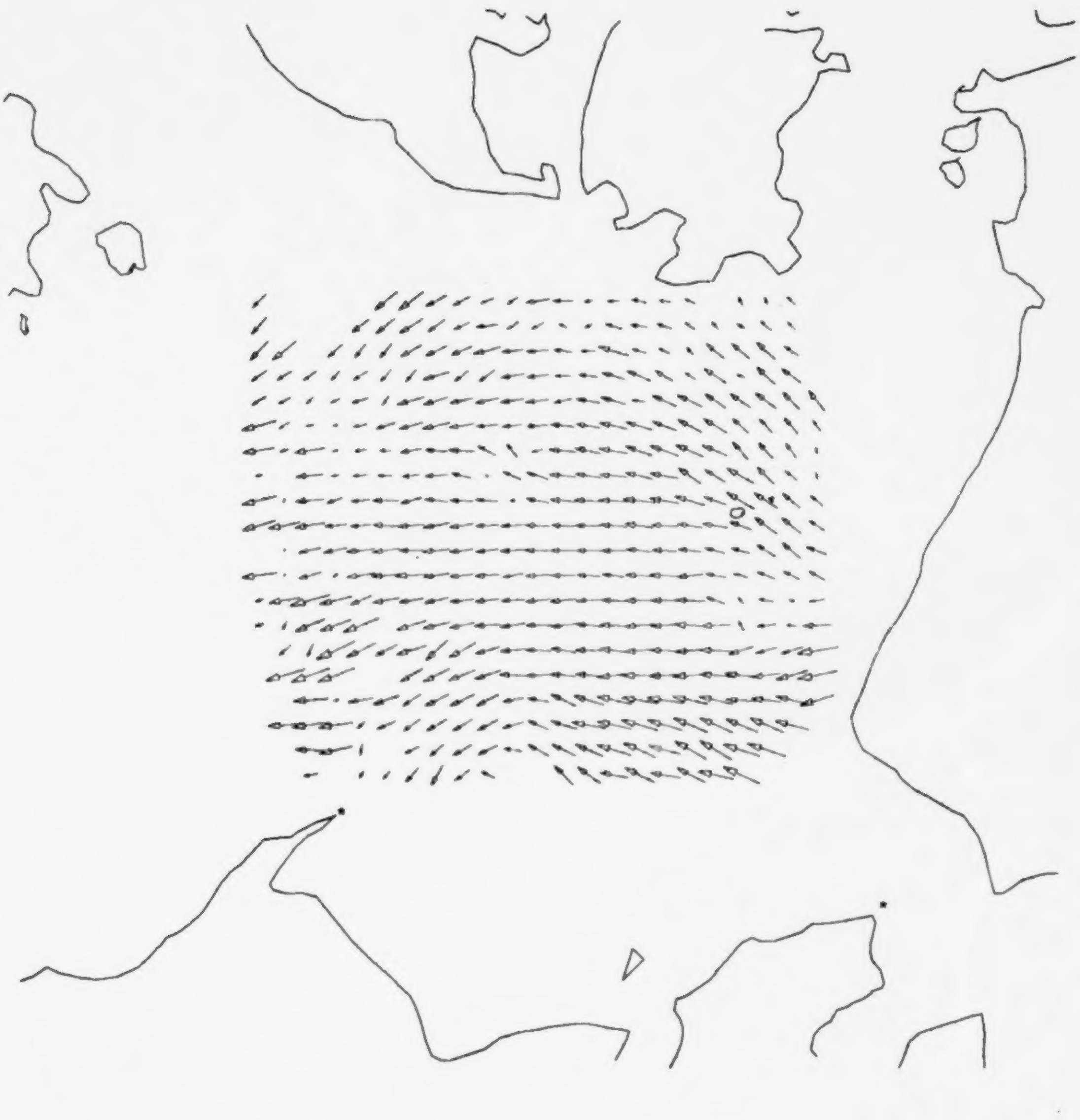


25 AUG 78 15: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 1.66

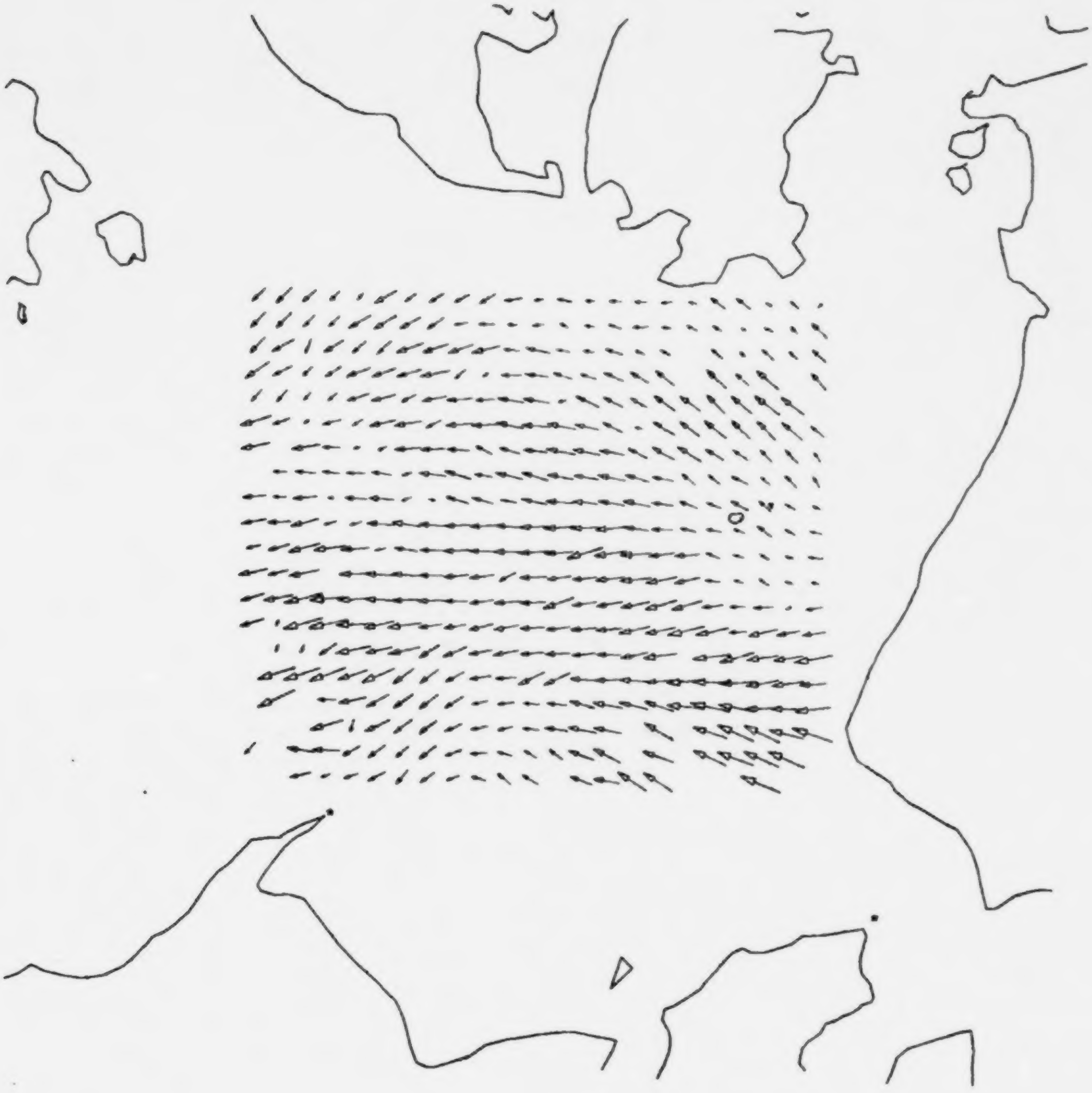


25 AUG 78 16: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

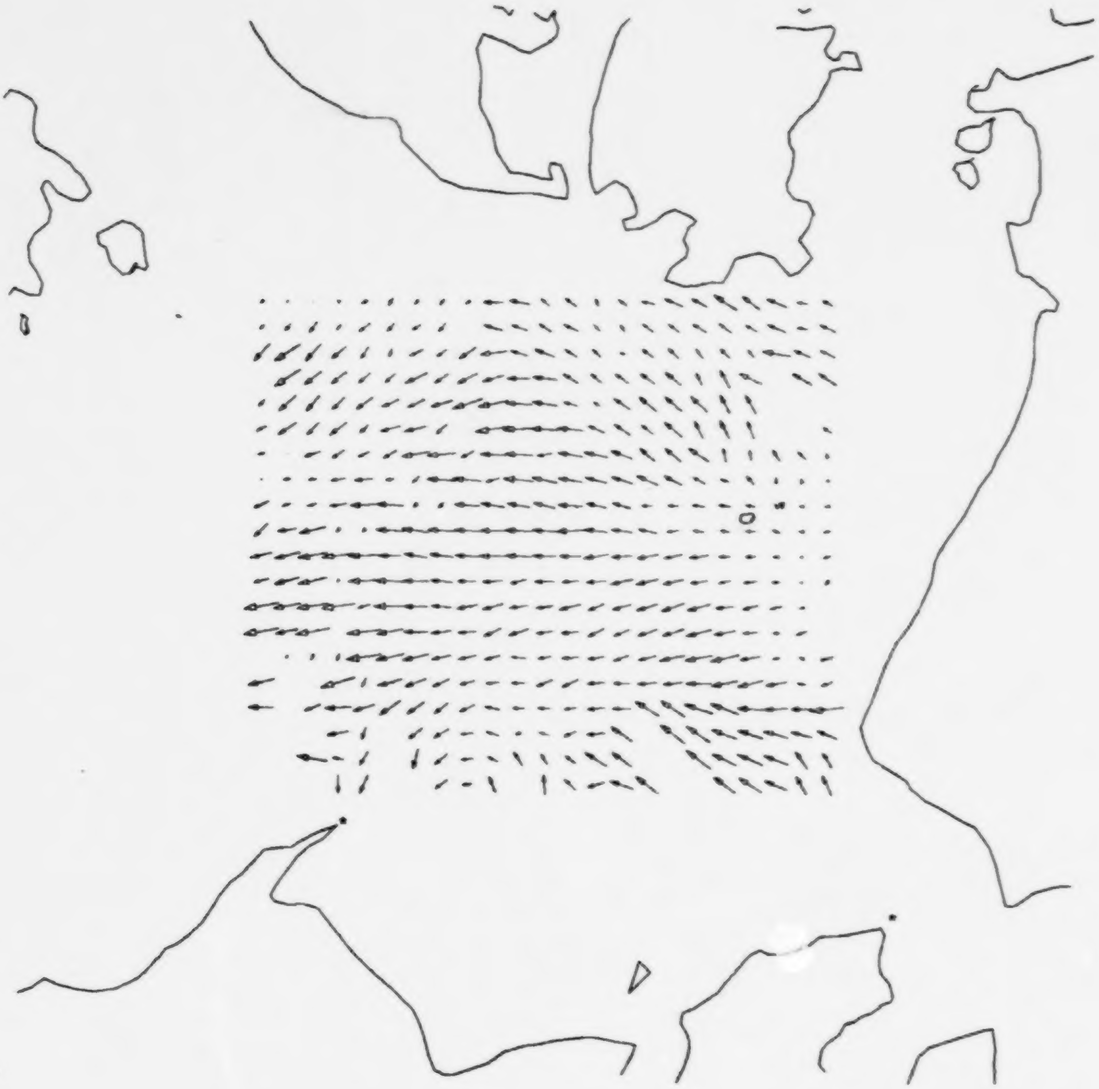
A 1.67



25 AUG 78 17: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

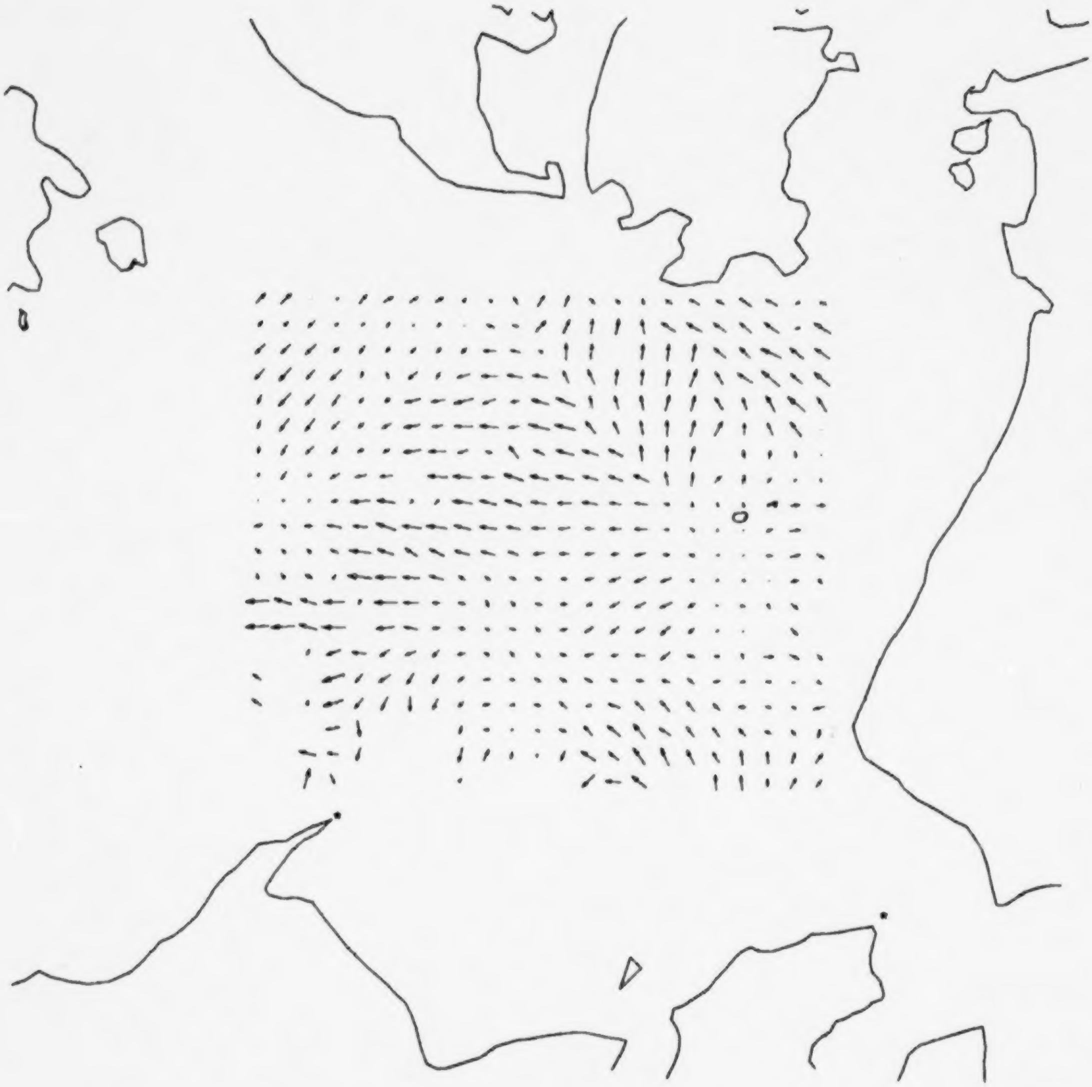
A 1.63



25 AUG 78 18: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [———————]
200 CM/S [———————]
TRUE NORTH ↑

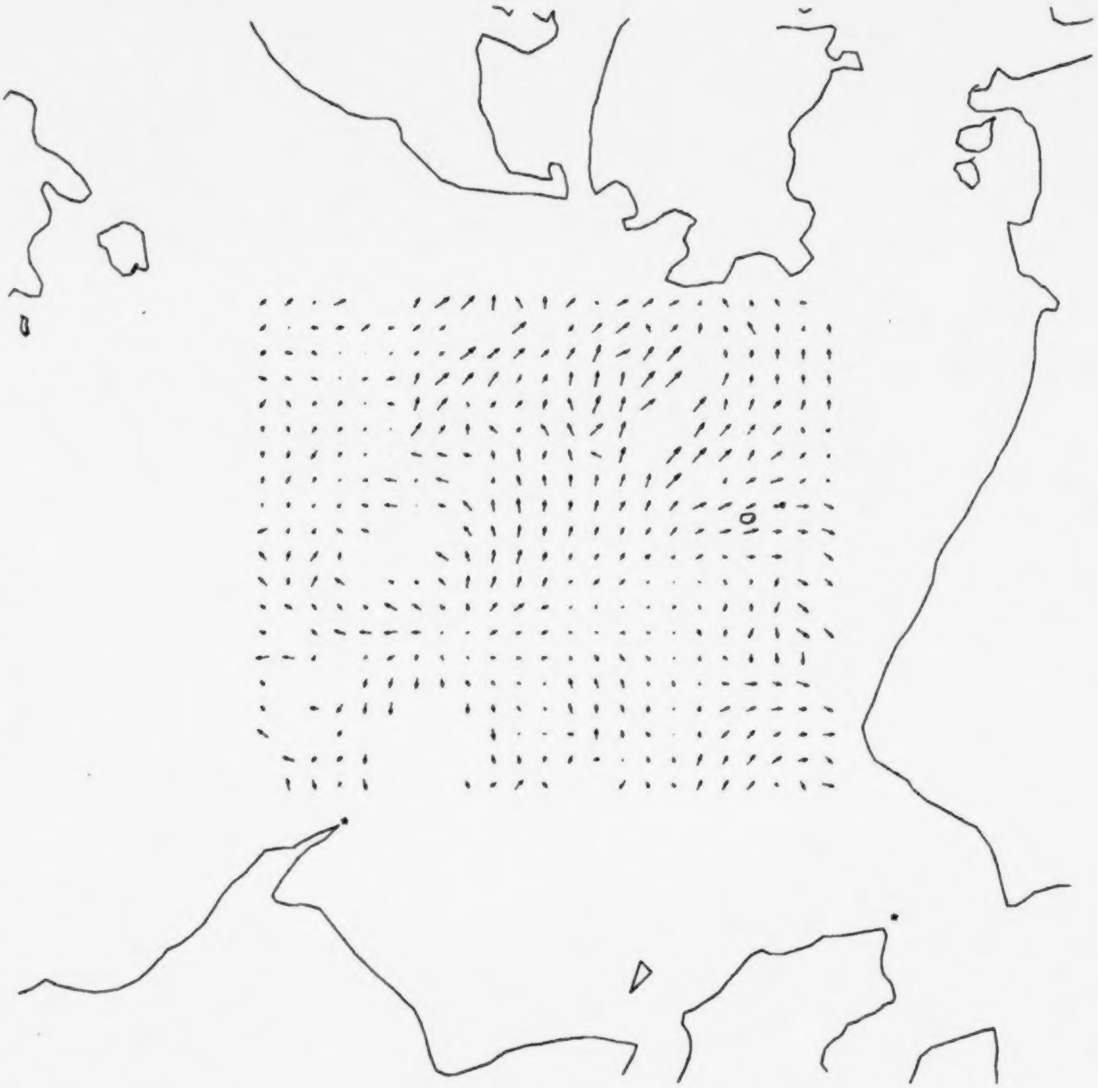
A 1.09



25 AUG 78 19: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [———————]
200 CM/S [———————]
TRUE NORTH ↑

A 1.70

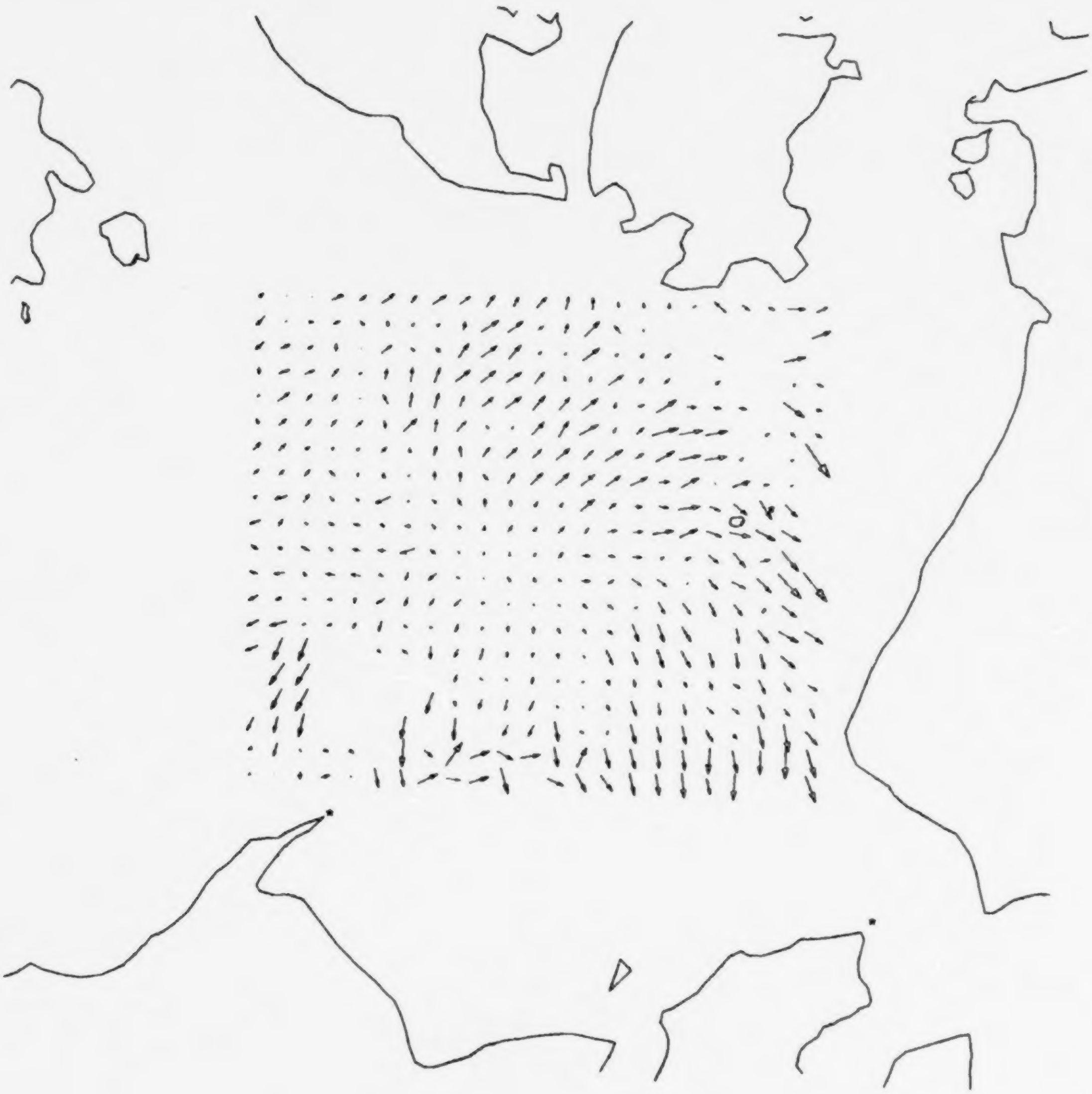


25 AUG 78 20: 0:00
DUNGENESS SPIT WASH.
POINT WILSON WASH.

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

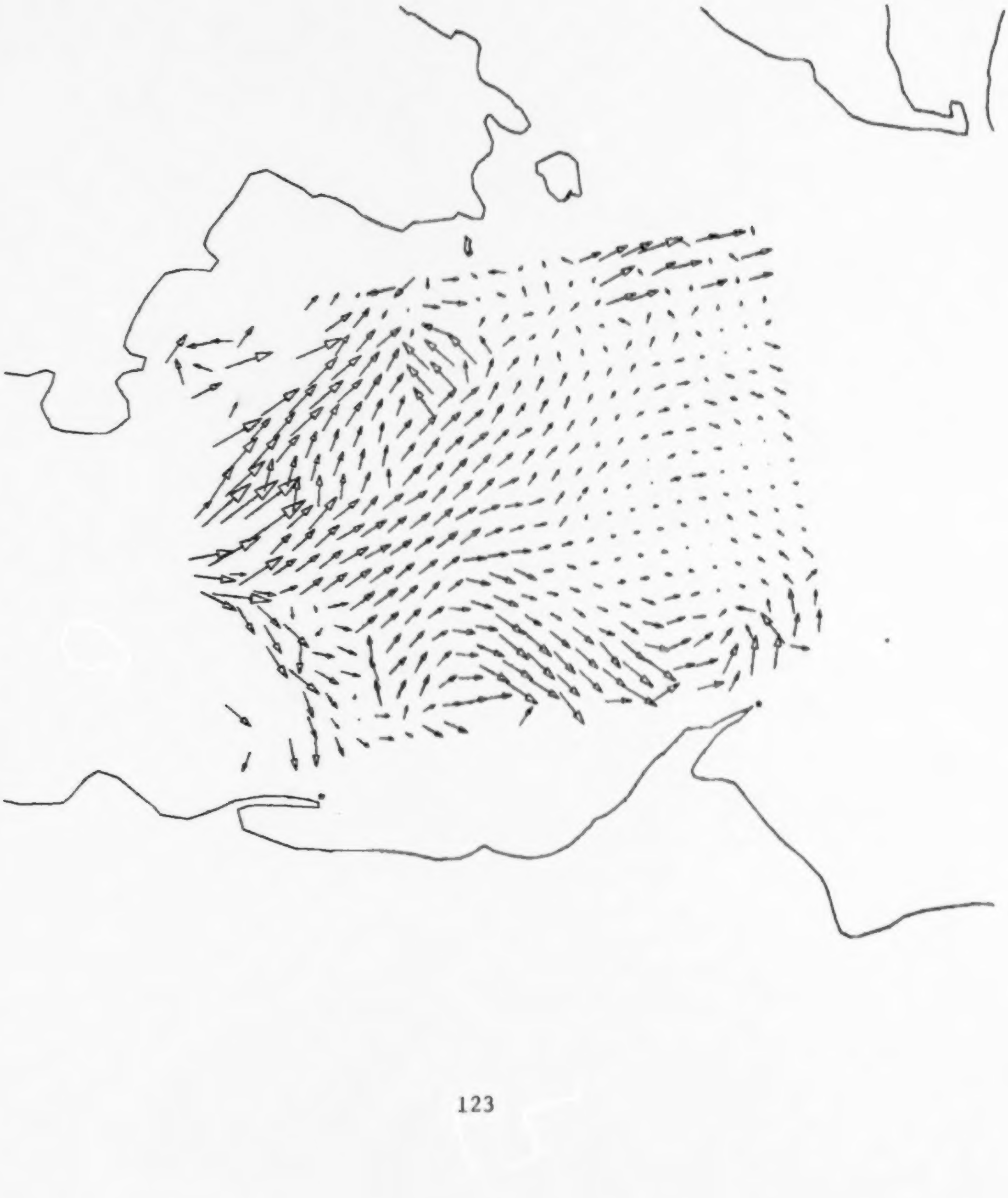
A 1.71



26-AUG-78 13:00:00
EDIZ HOOK WASH.
DUNGENESS SPIT WASH

6 KM [------------------]
200 CM/S [------------------]
TRUE NORTH ↑

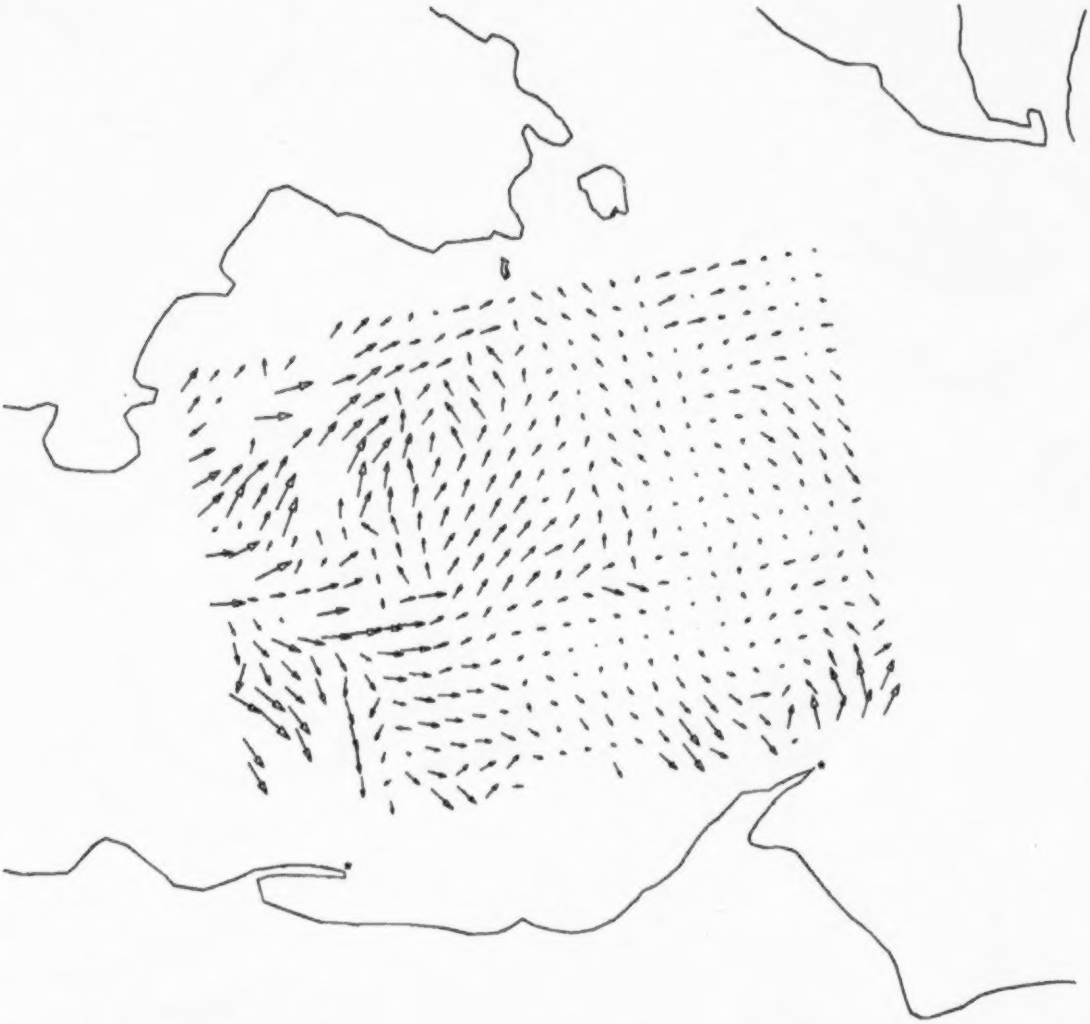
A 2.00



26 AUG 78 14: 0:00
EDIZ HOOK WASH.
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

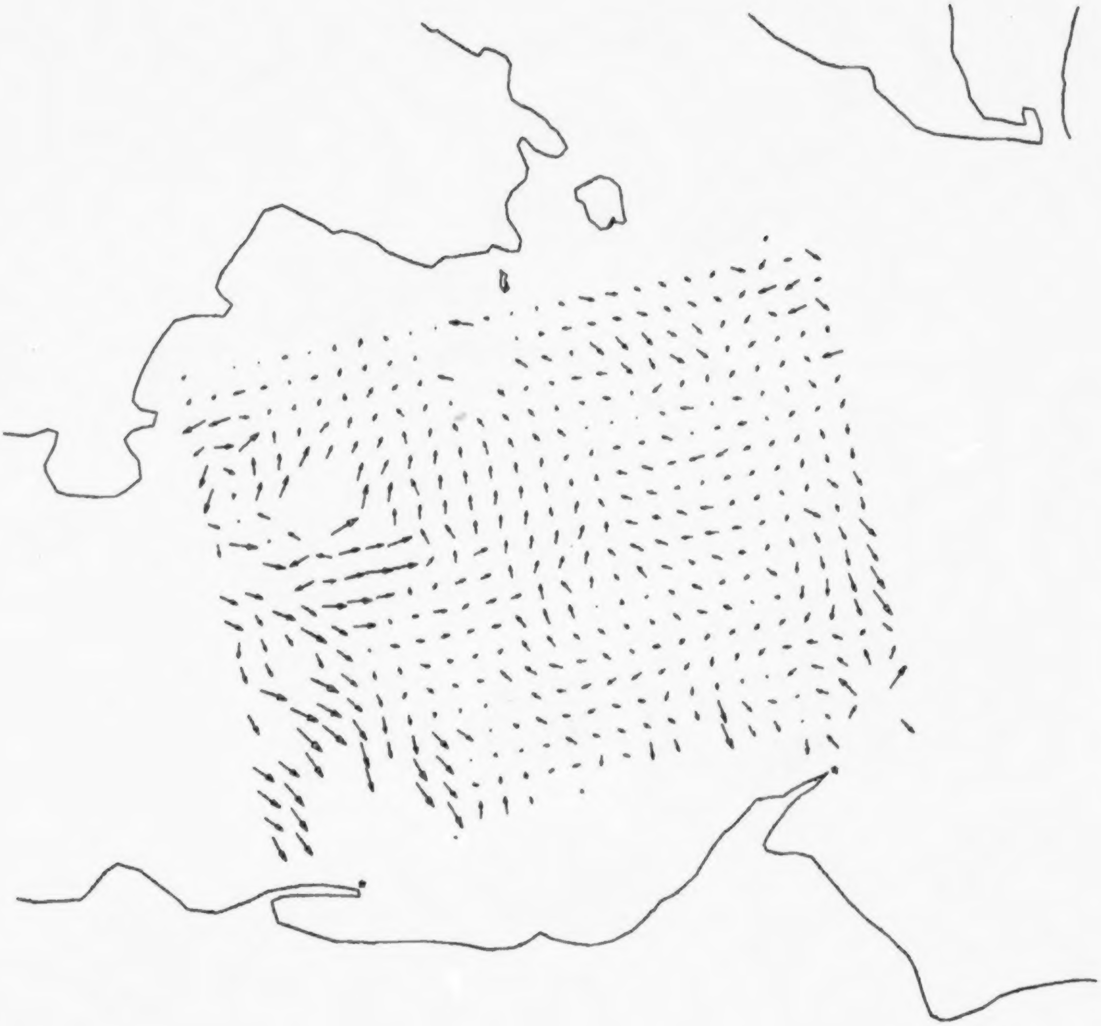
A 2.01



26 AUG 78 15: 0:00
EDIZ HOOK WASH.
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

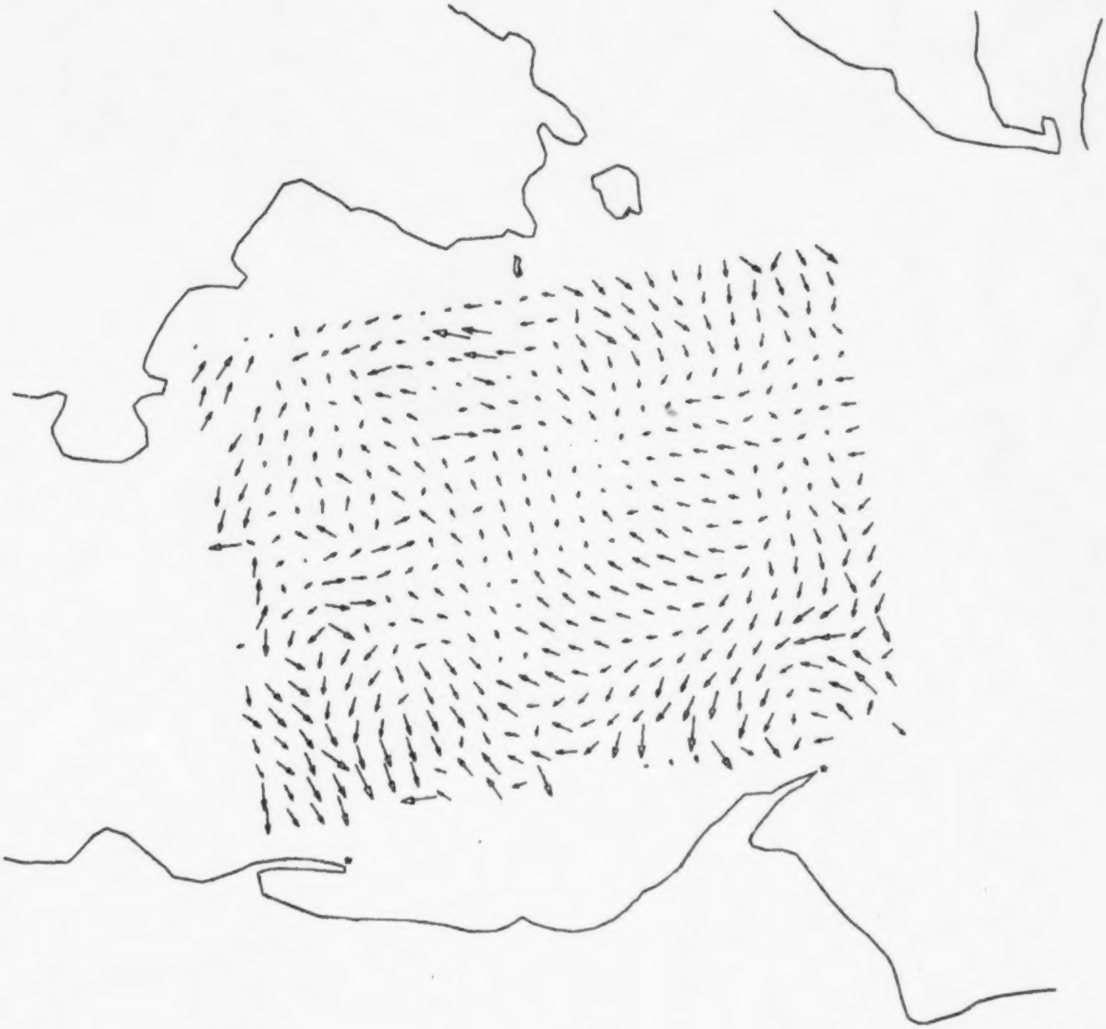
A 2.02



26 AUG 78 16: 0:00
EDIZ HOOK WASH.
DUNGENESS SPIT WASH

6 KM [————————]
200 CM/S [————————]
TRUE NORTH ↑

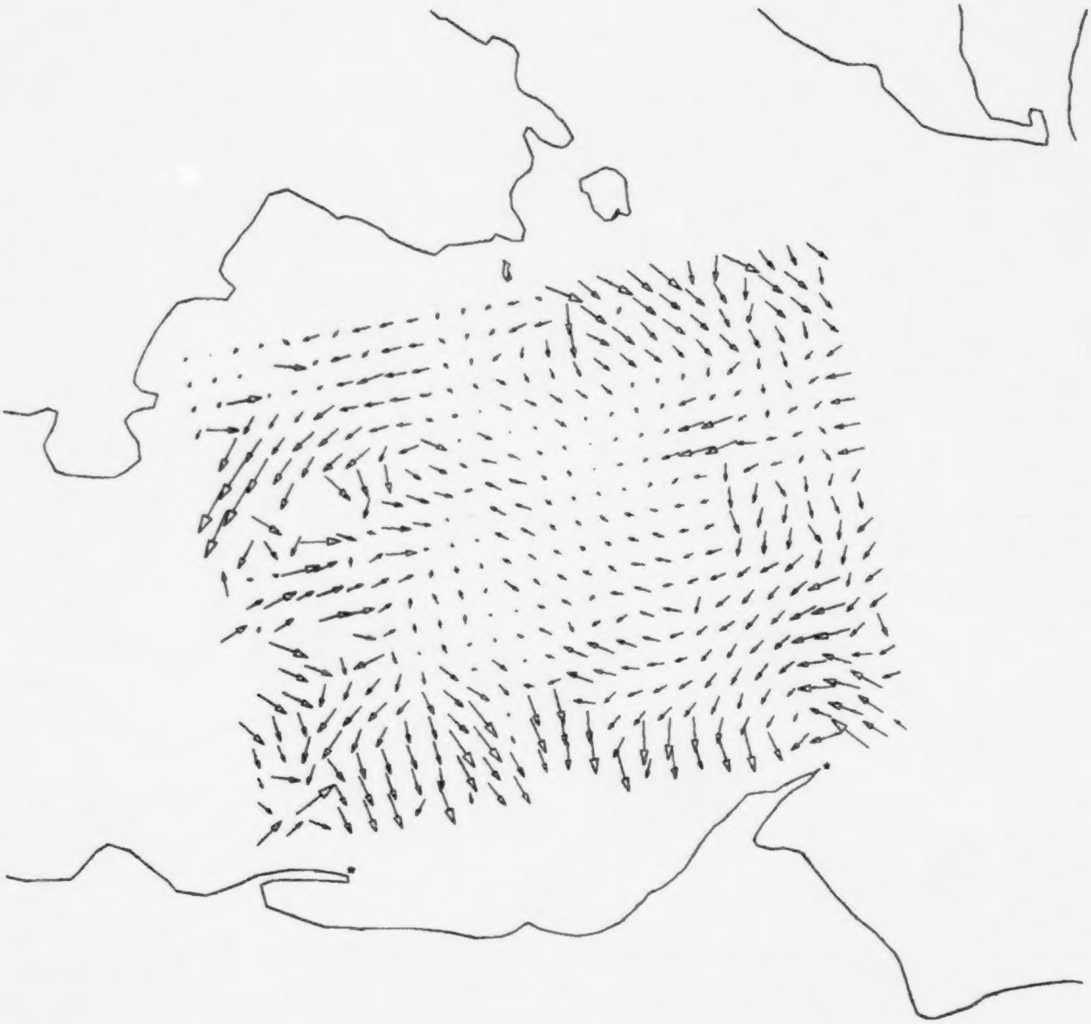
A 2.33



26 AUG 78 17: 0:00
EDIZ HOOK WASH.
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

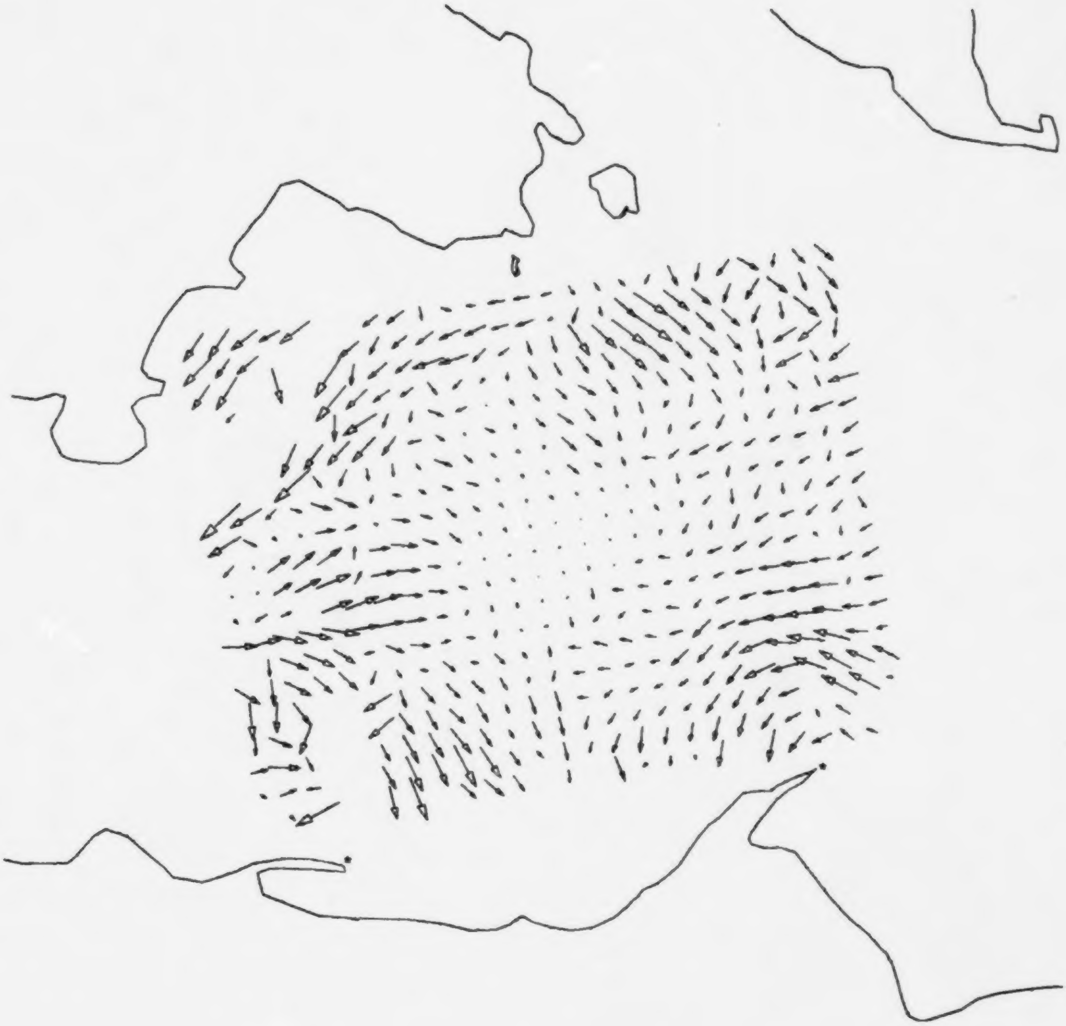
A 2.04



26 AUG 78 18: 0:00
EDIZ HOOK WASH.
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

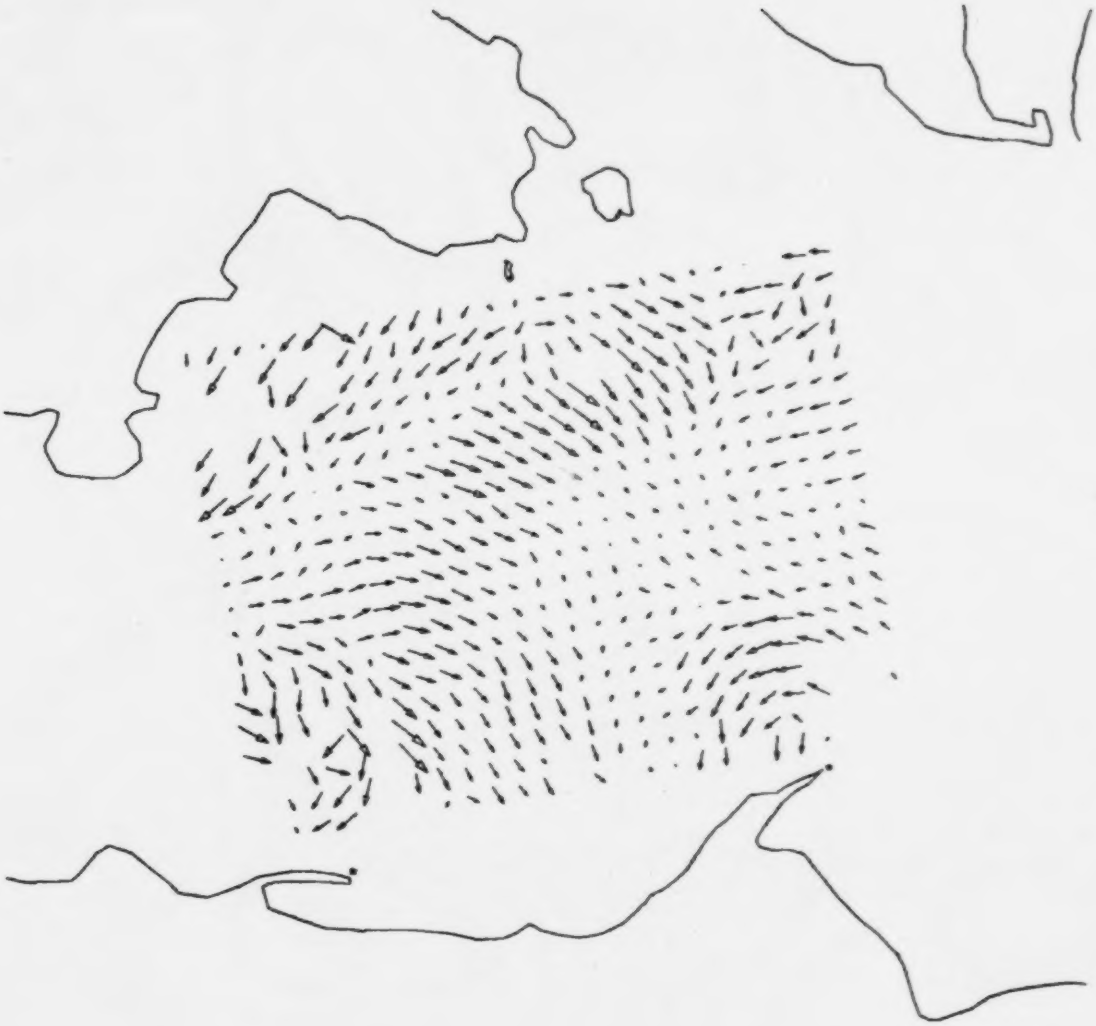
A 2.05



26 AUG 78 19: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [-------------]
200 CM/S [-------------]
TRUE NORTH ↑

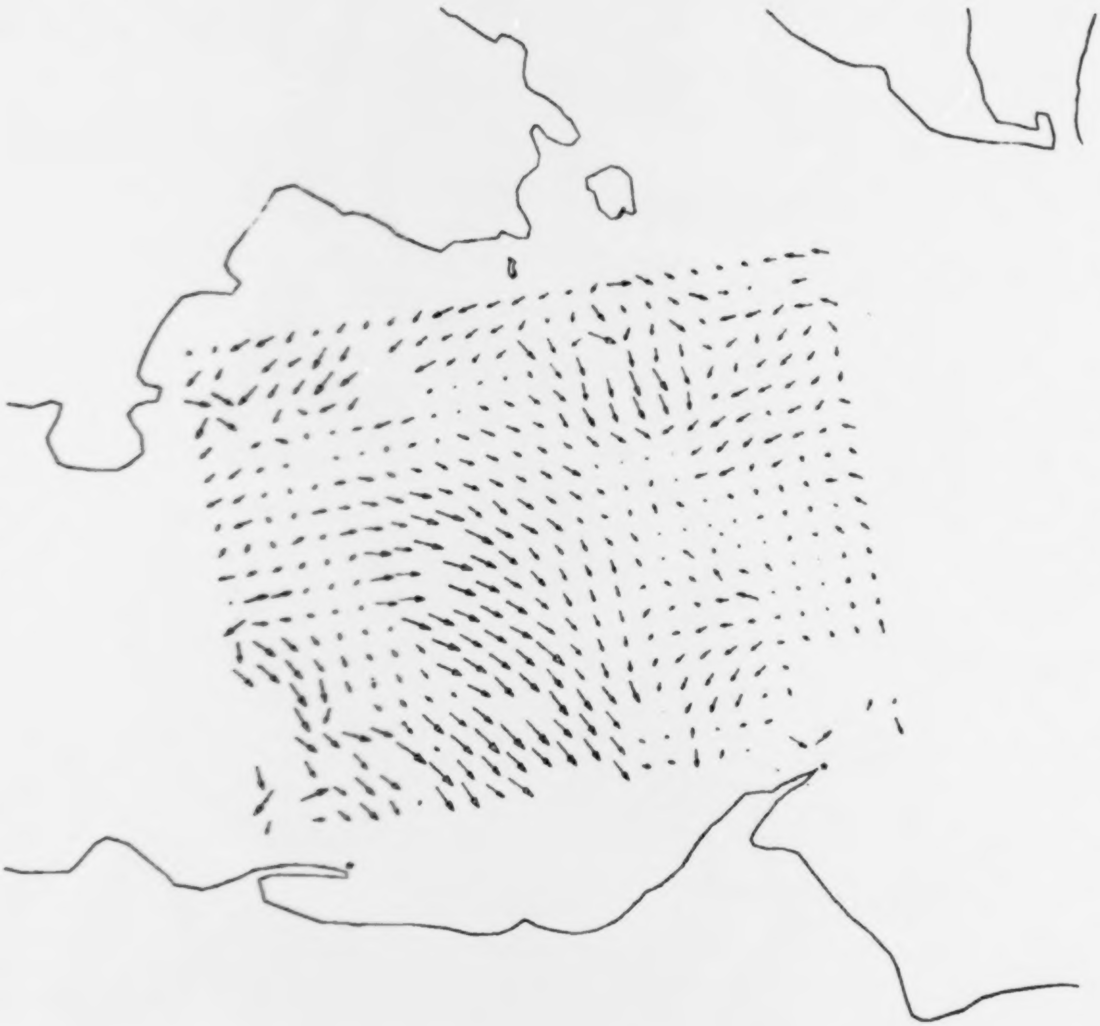
A 2.36



26 AUG 78 20: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [-----------------]
200 CM/S [-----------------]
TRUE NORTH ↑

A 2.07

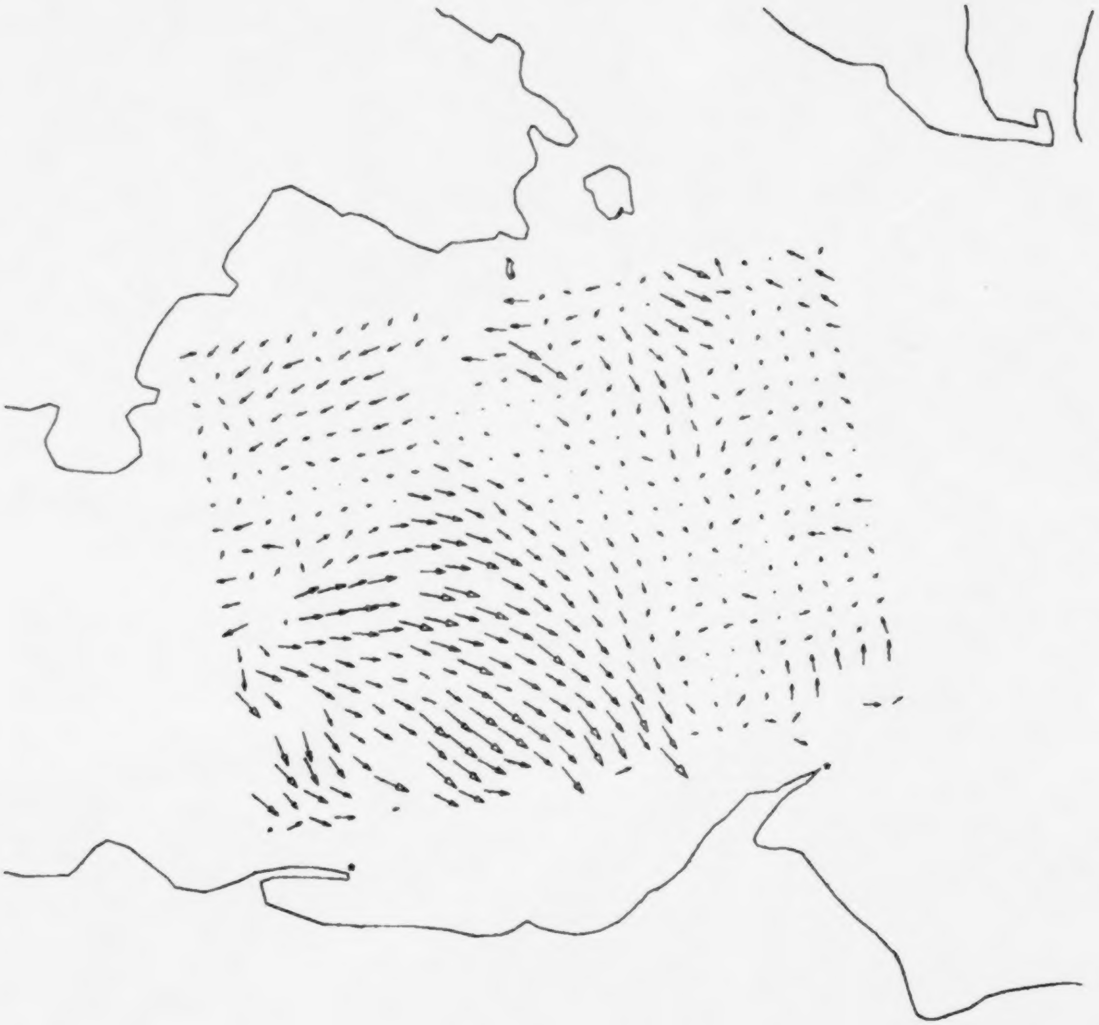


26 AUG 78 21: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [———————]
200 CM/S [———————]

TRUE NORTH ↑

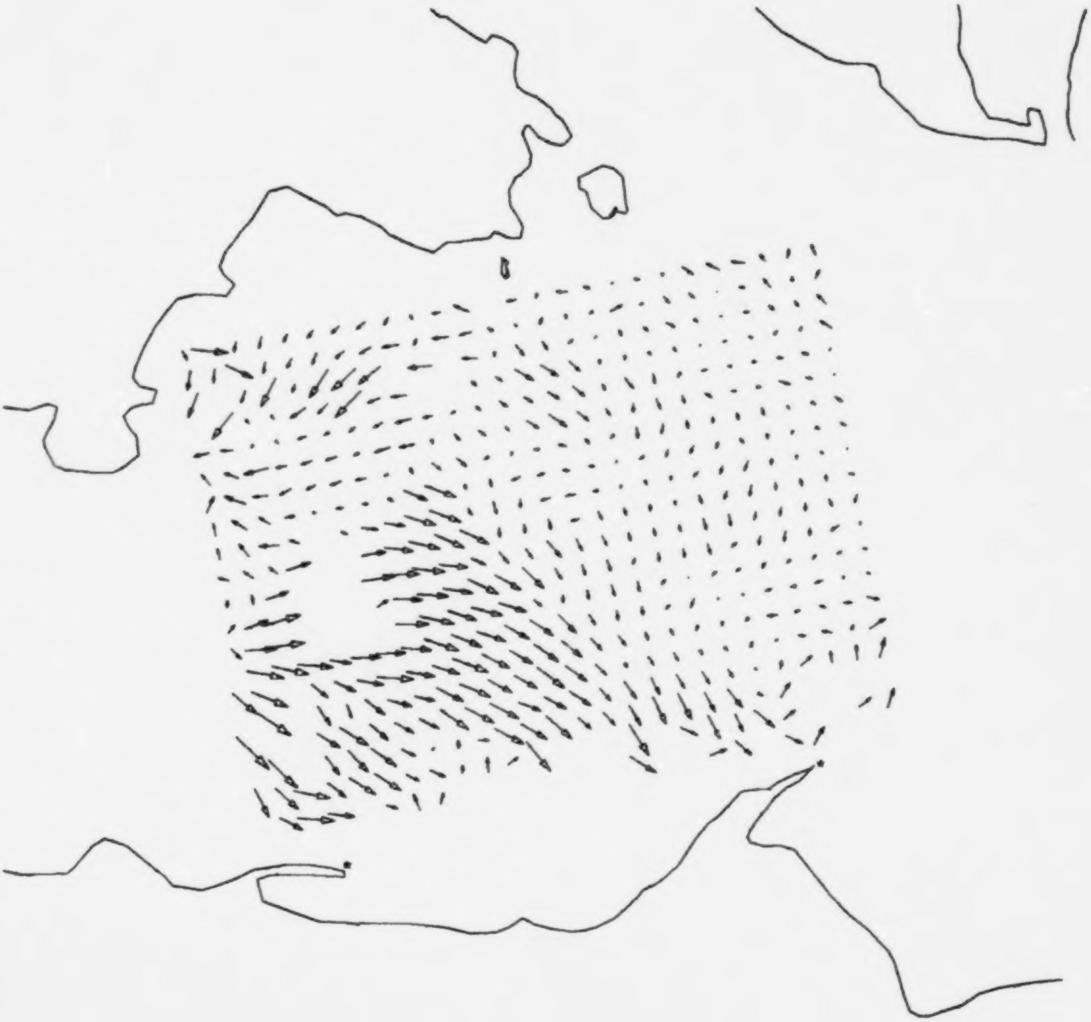
A 2.08



26 AUG 78 22: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [-----------]
200 CM/S [-----------]
TRUE NORTH ↑

A 2.09

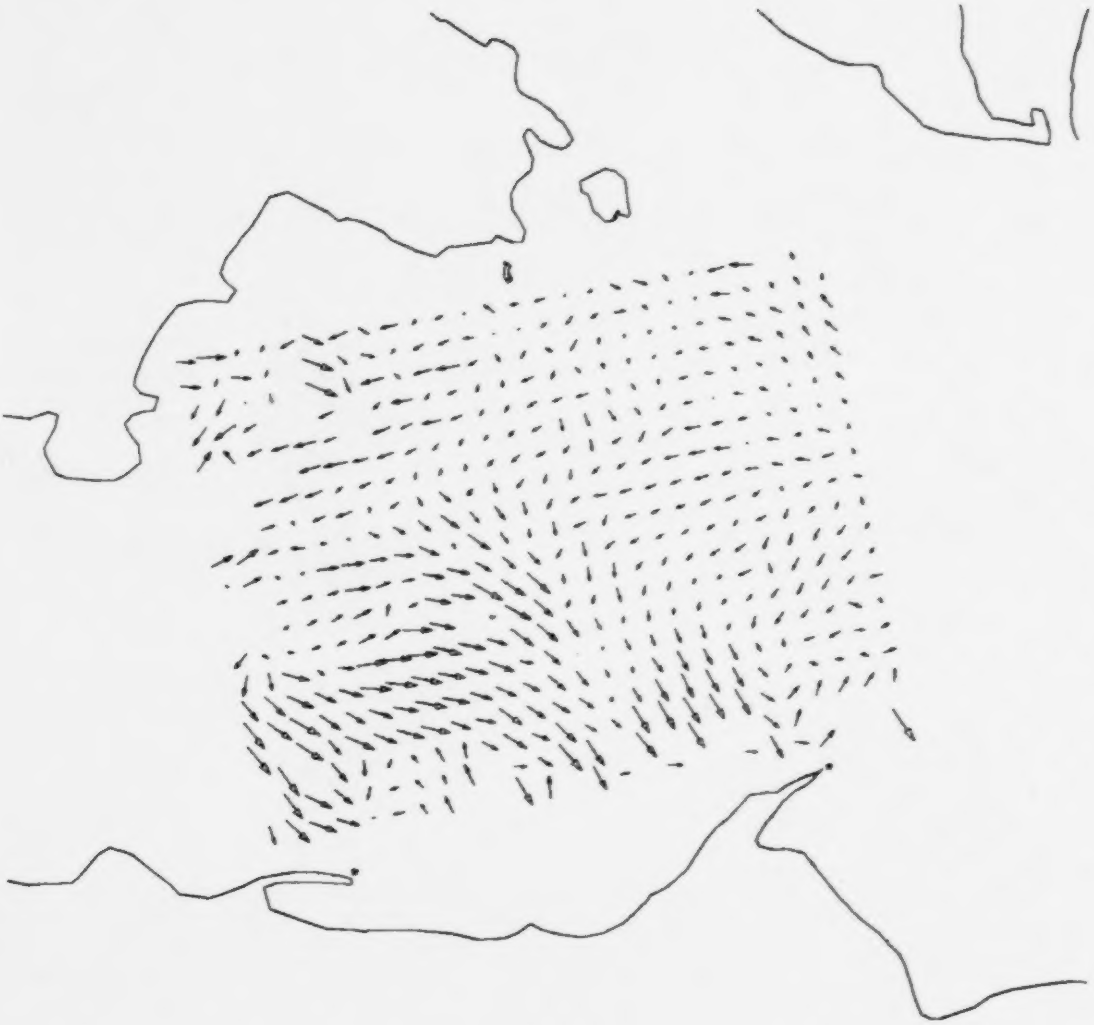


26 AUG 78 23: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

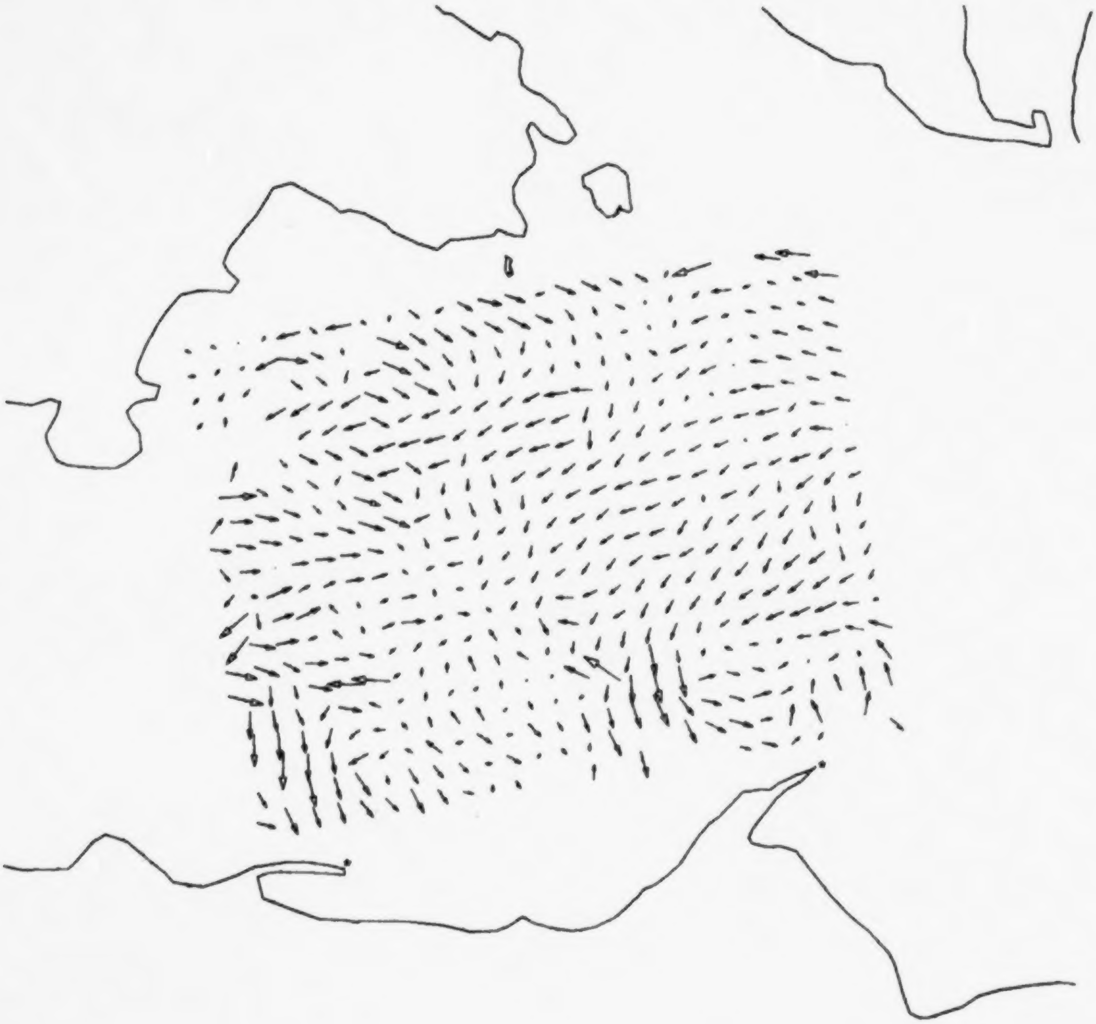
A 2.10



27 AUG 78   0: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [———————]
200 CM/S [———————]
TRUE NORTH ↑

A 2.11

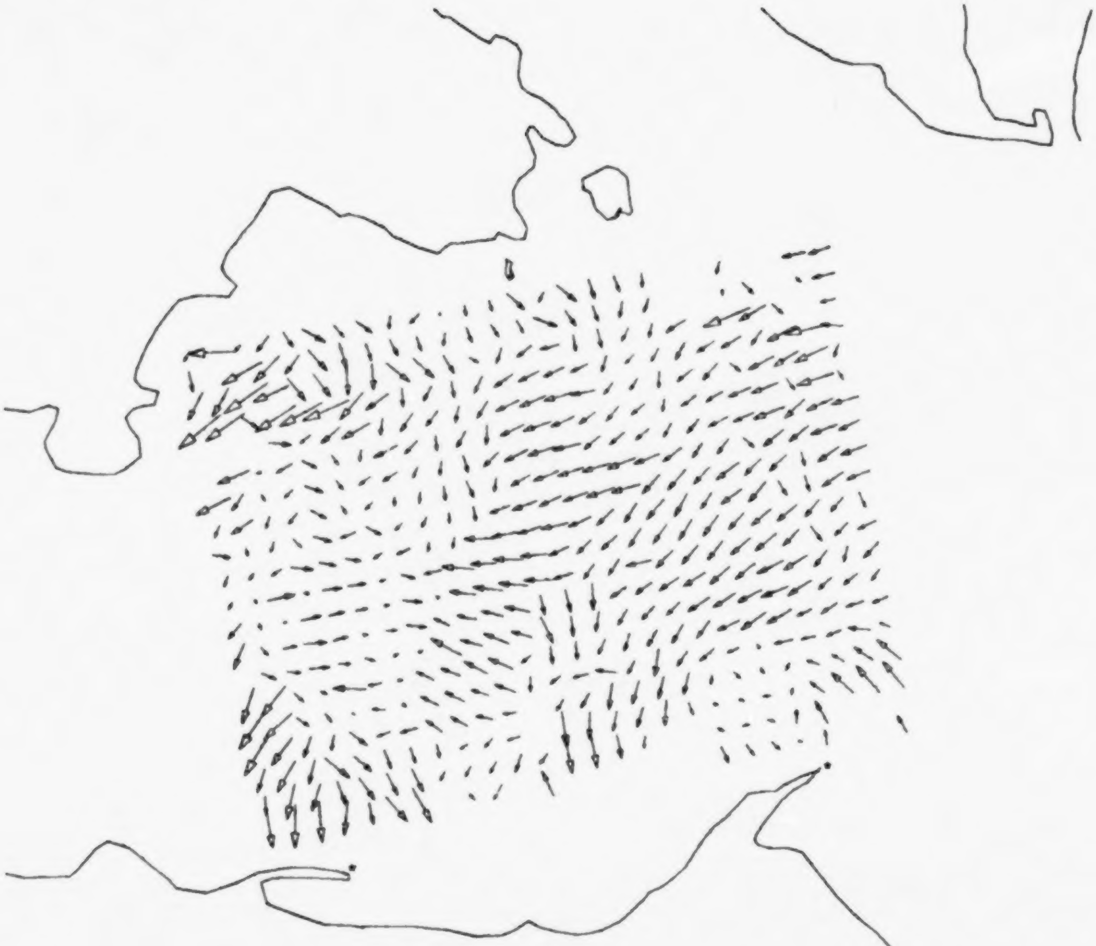


27 AUG 78   1: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [――――――――]
200 CM/S [――――――――]

TRUE NORTH ↑

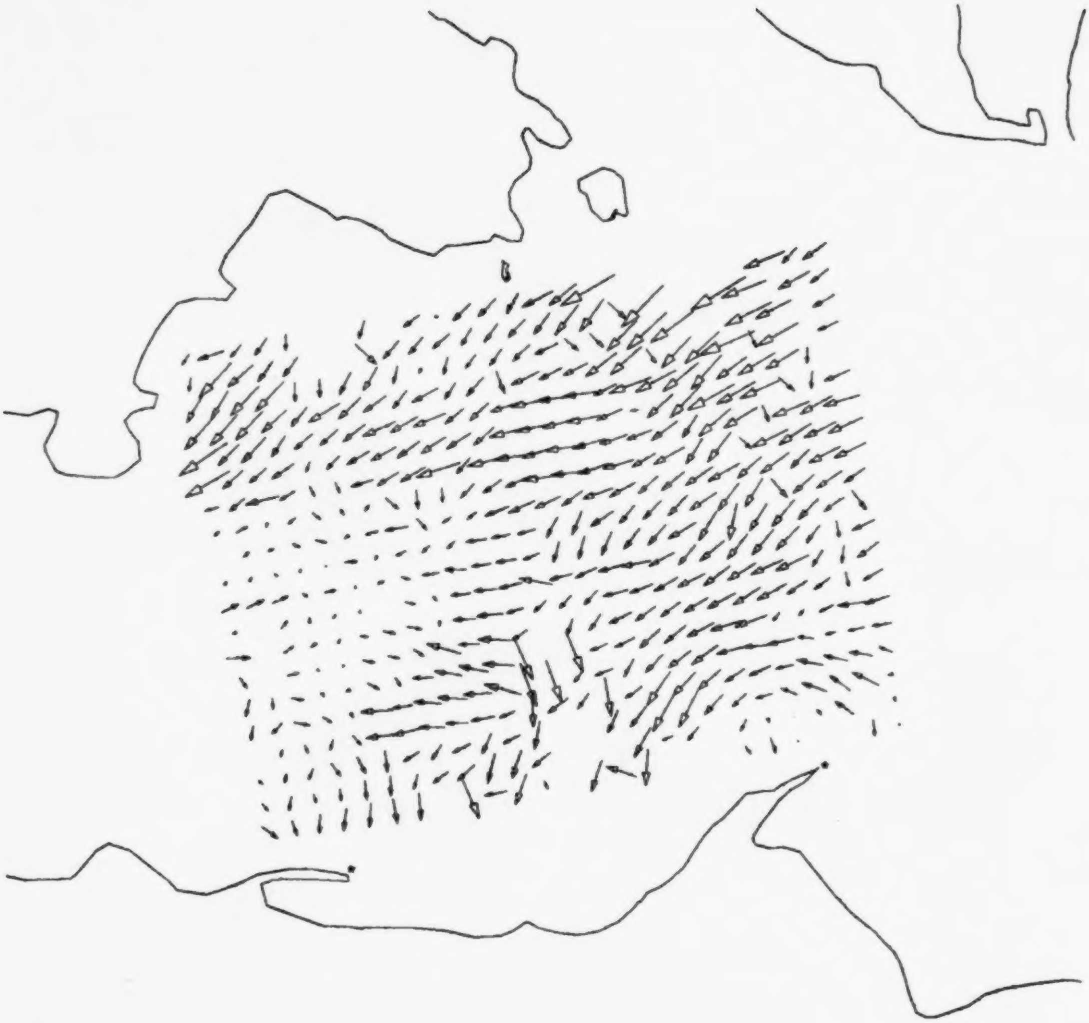
A 2.12



27 AUG 78   2: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

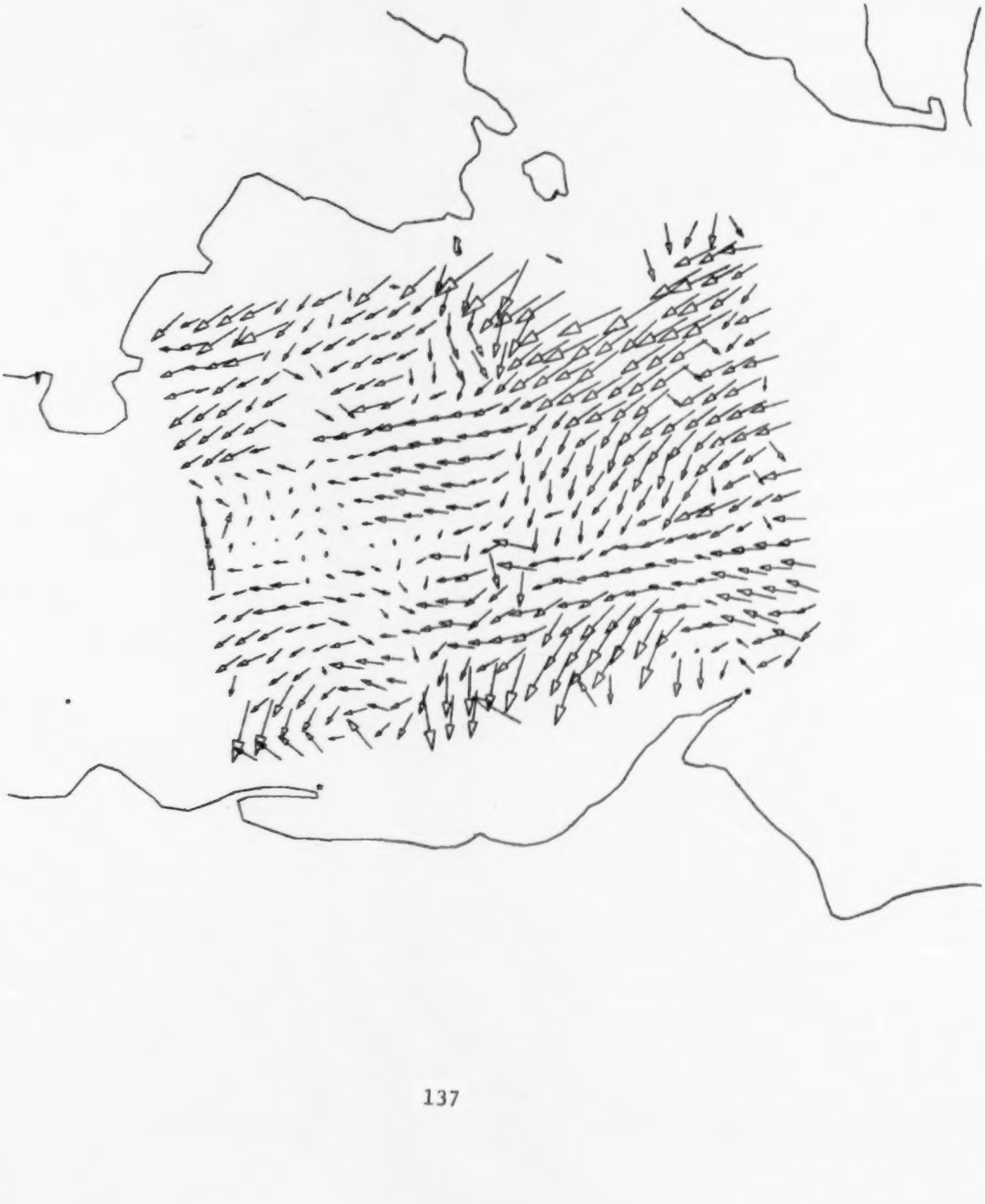
A 2.13



27 AUG 78 3: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [————]
200 CM/S [————]
TRUE NORTH ↑

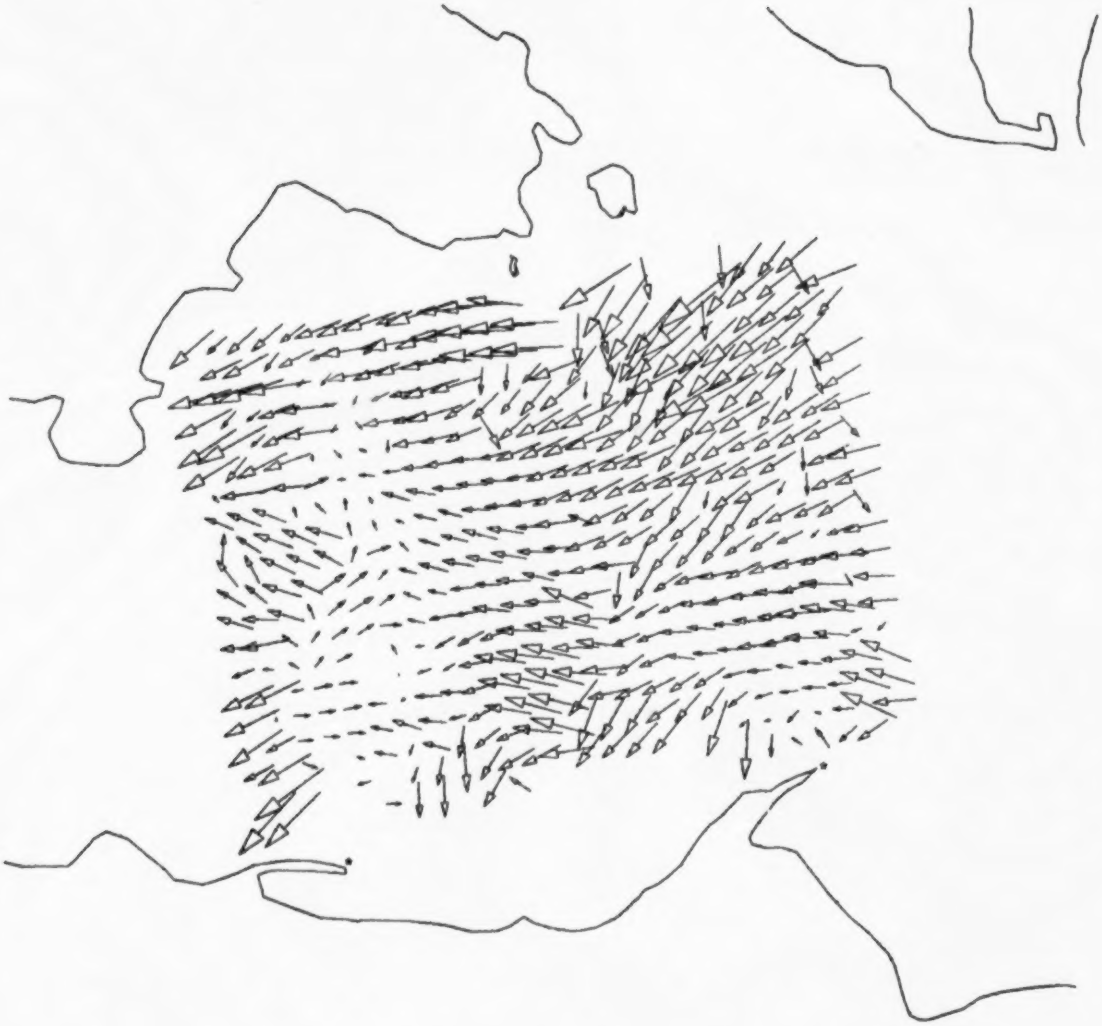
A 2.14



27 AUG 78   4: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

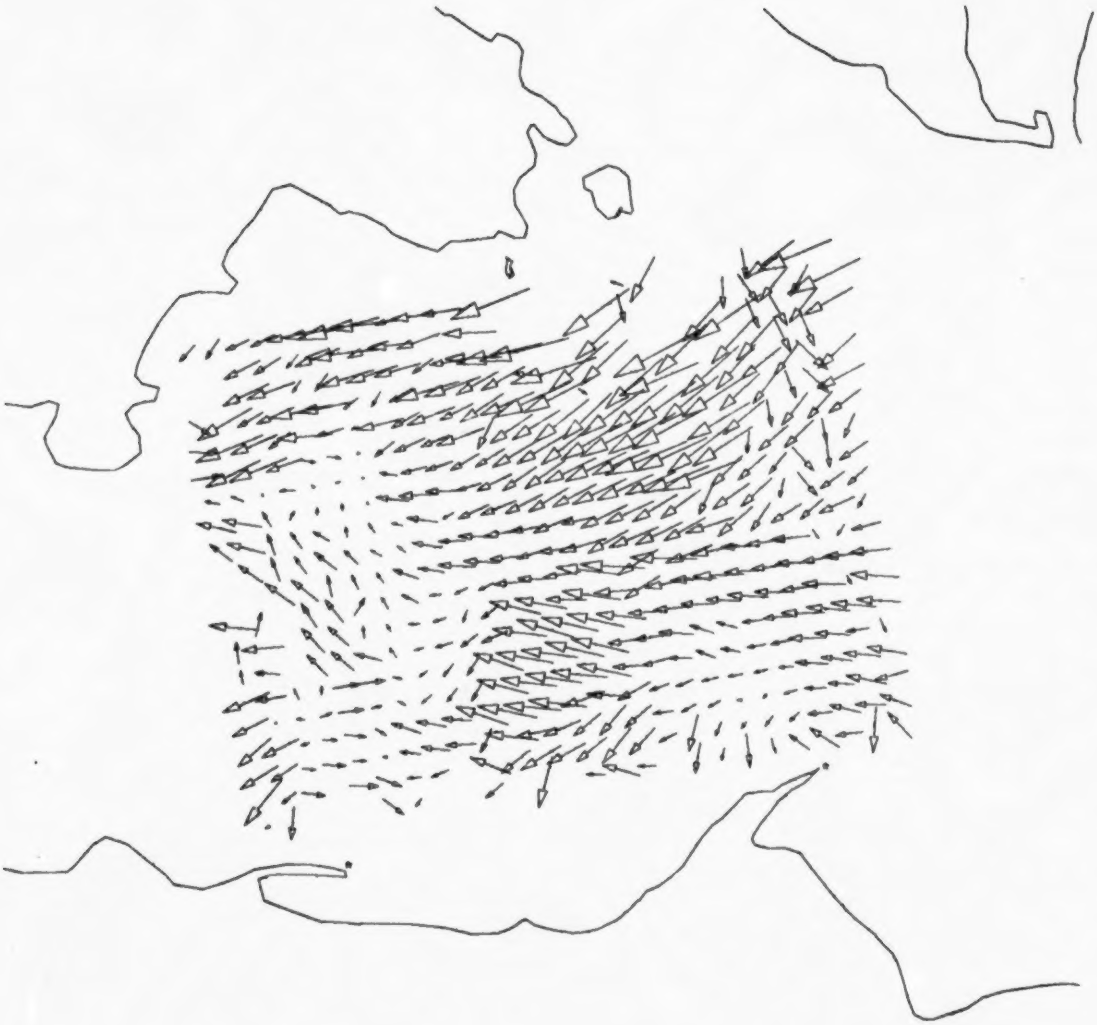
A 2.15



27 AUG 78   5: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

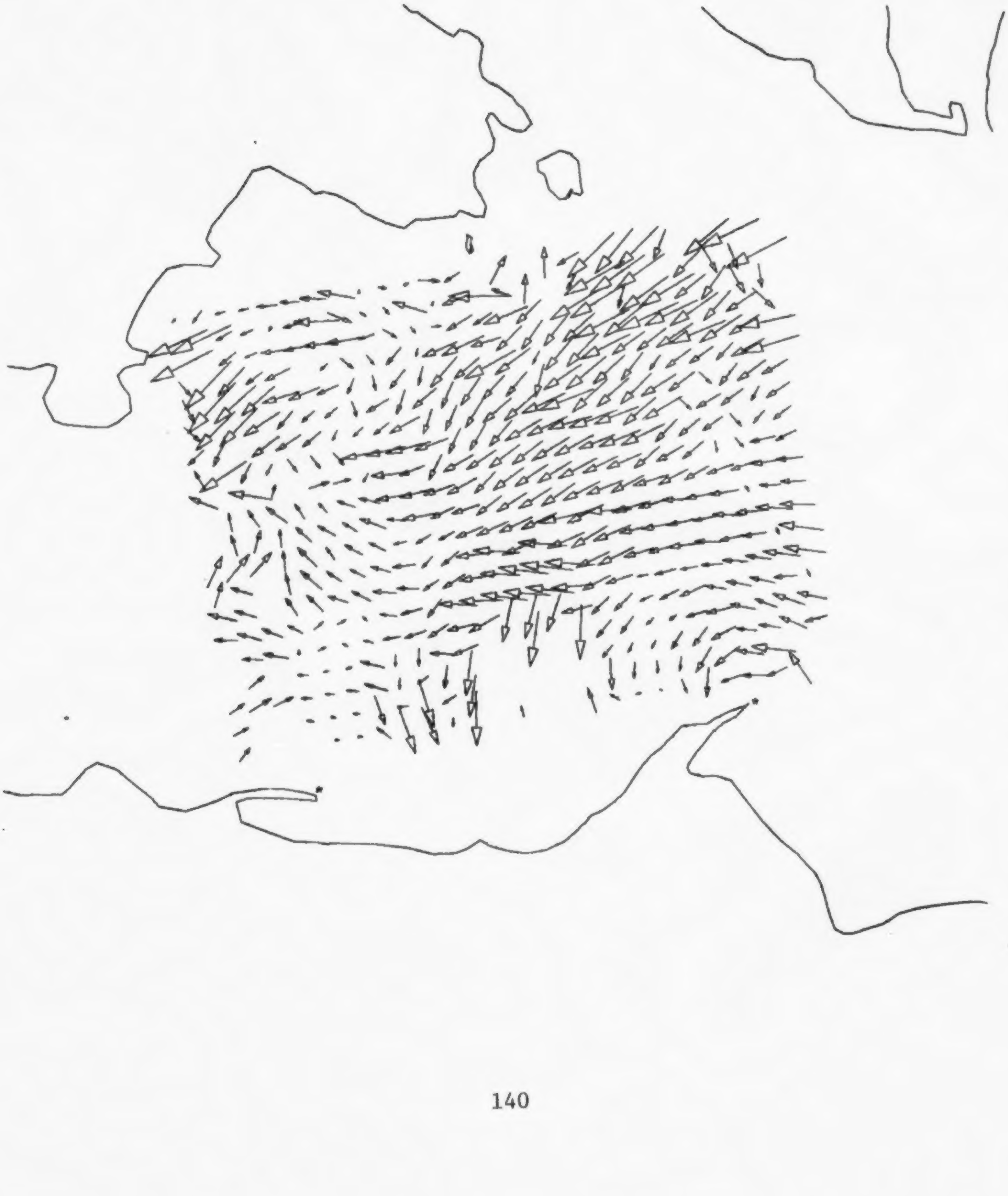
A 2.16



27 AUG 78 6: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [———————]
200 CM/S [———————]
TRUE NORTH ↑

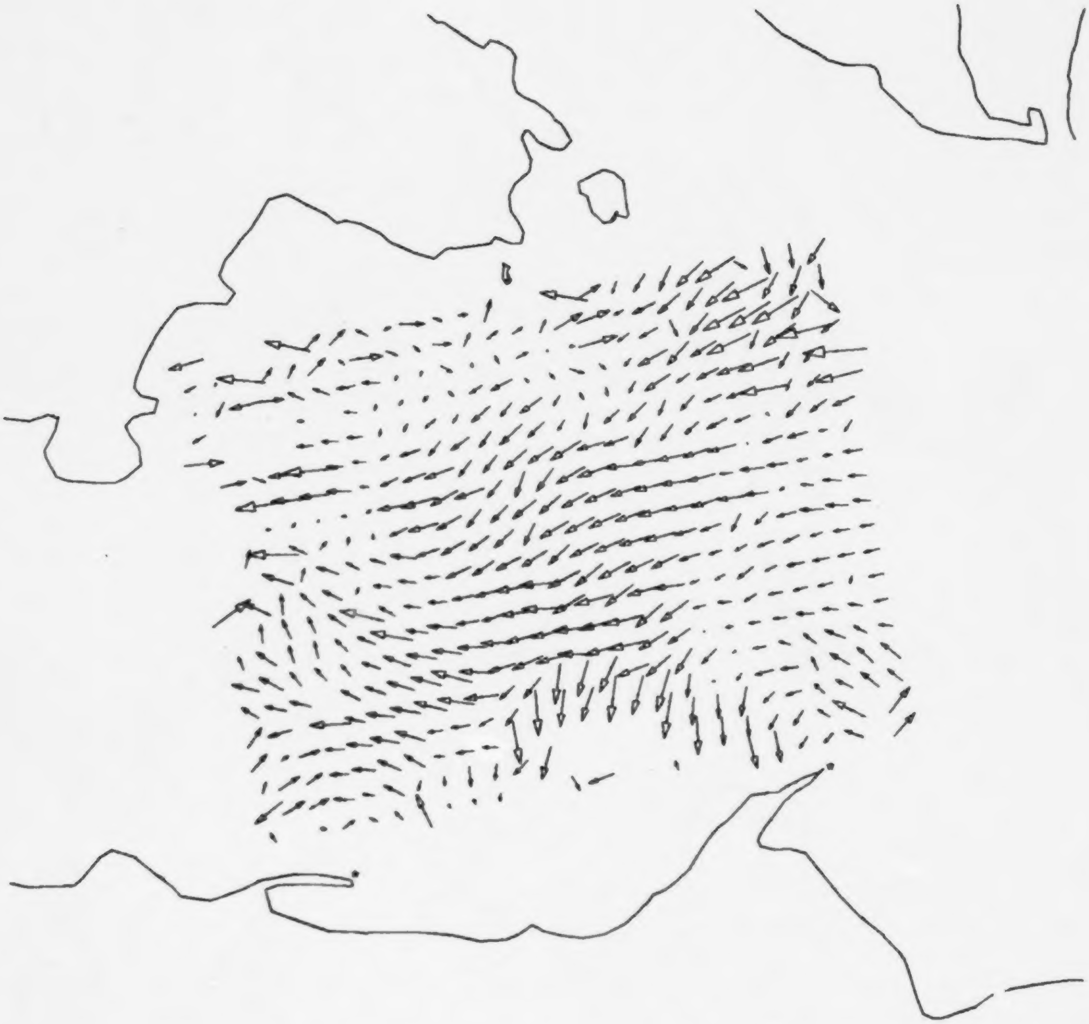
A 2.17



27 AUG 78 7: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

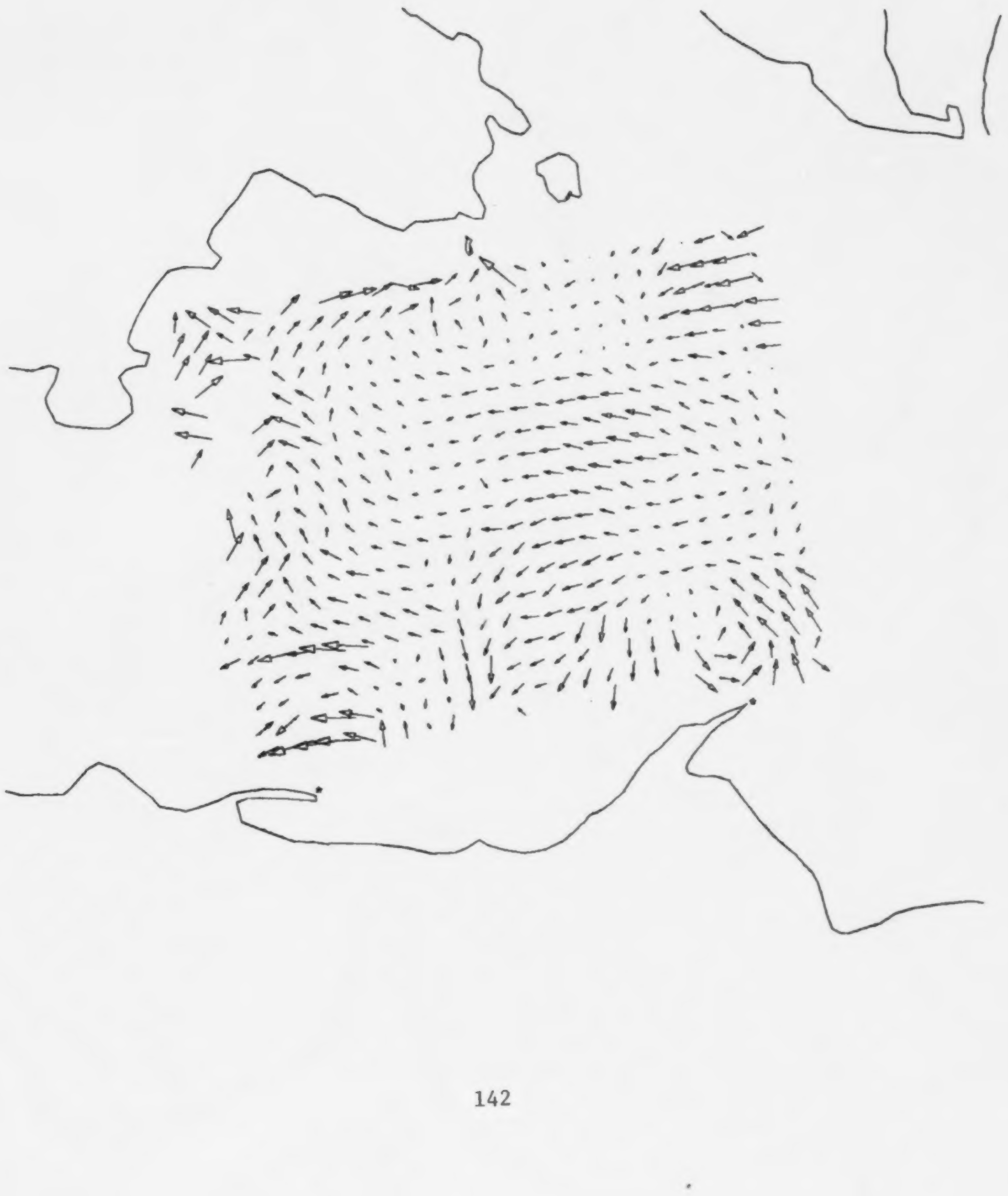
A 2.18



27 AUG 78   8: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

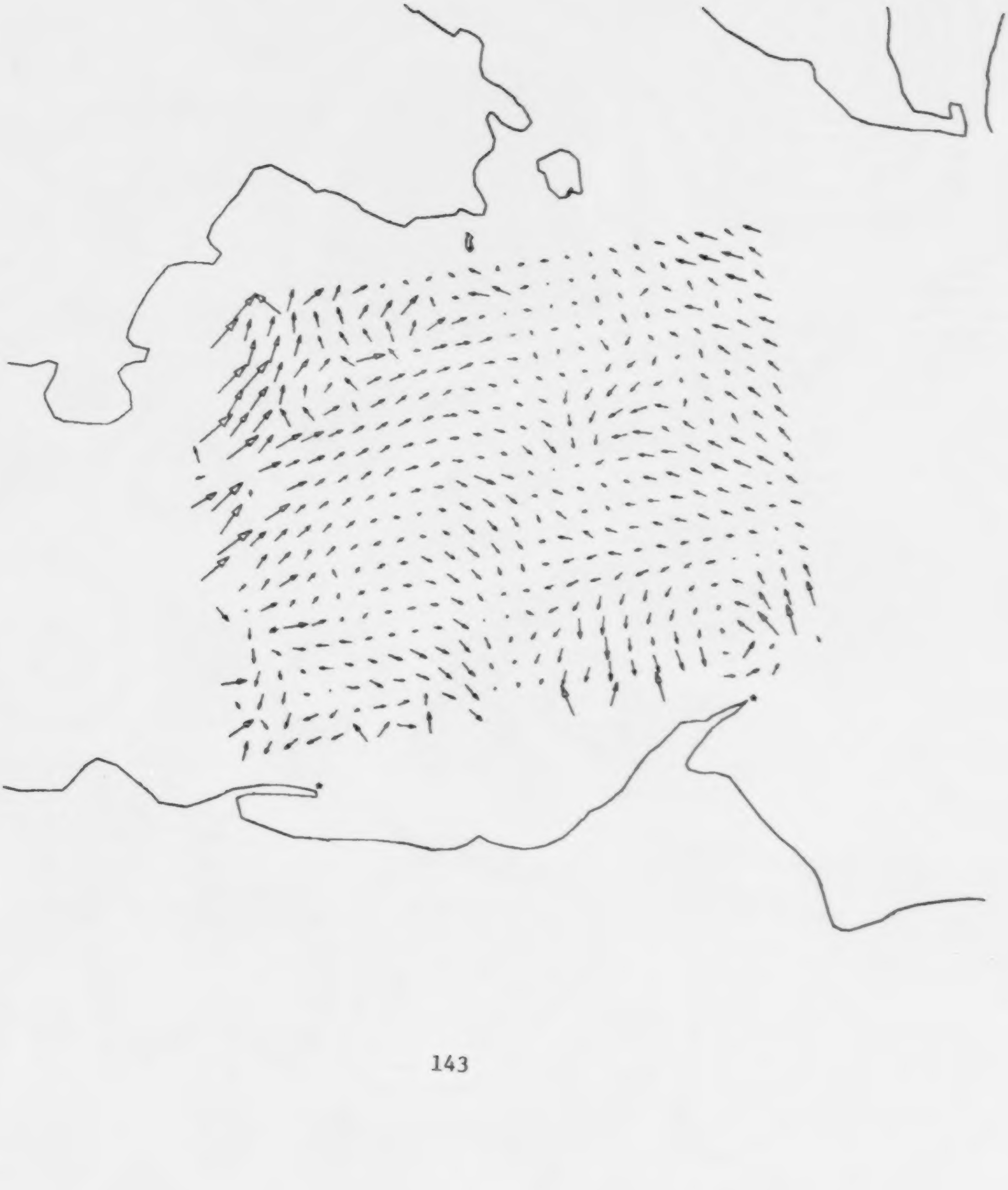
A 2.19



27 AUG 78   9: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

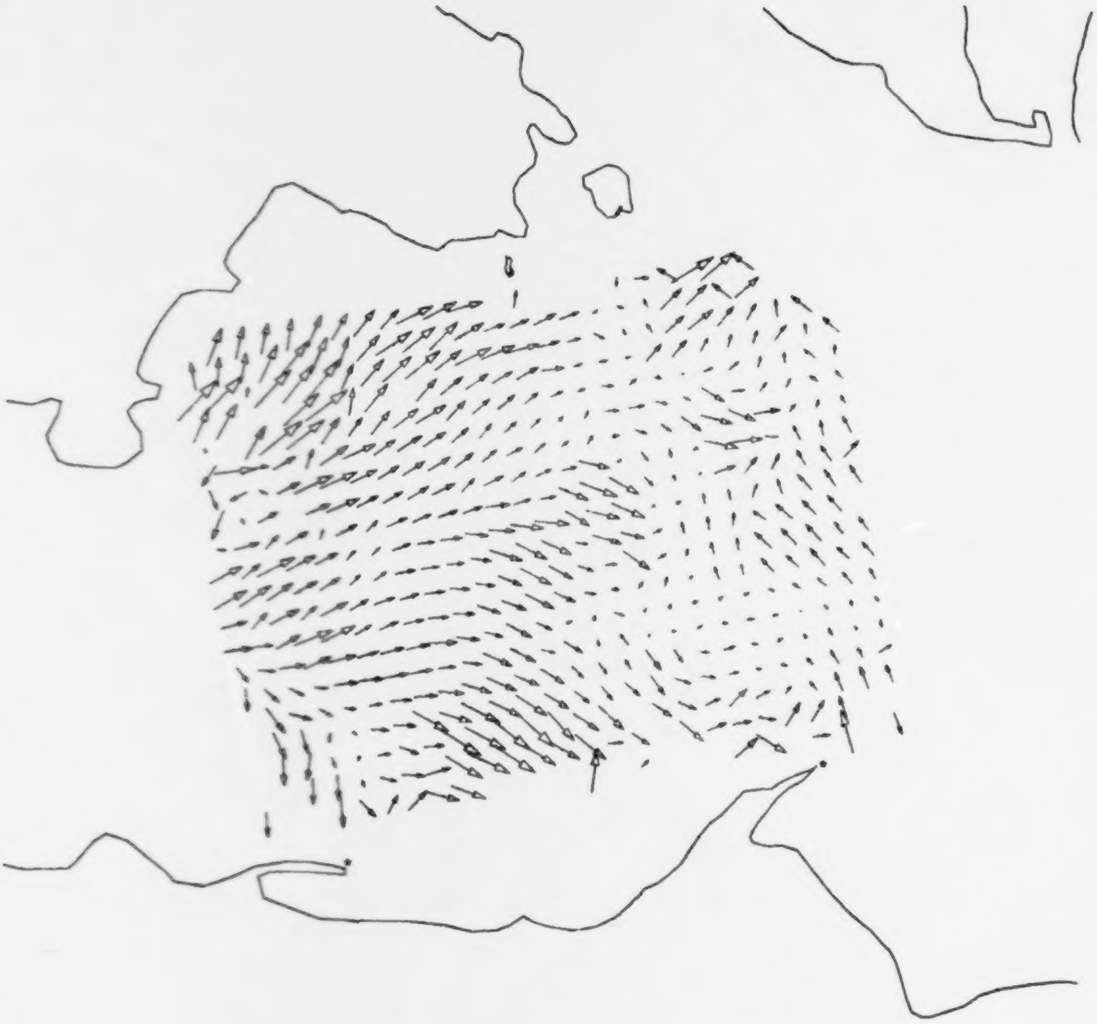
A 2.20



27 AUG 78 10: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

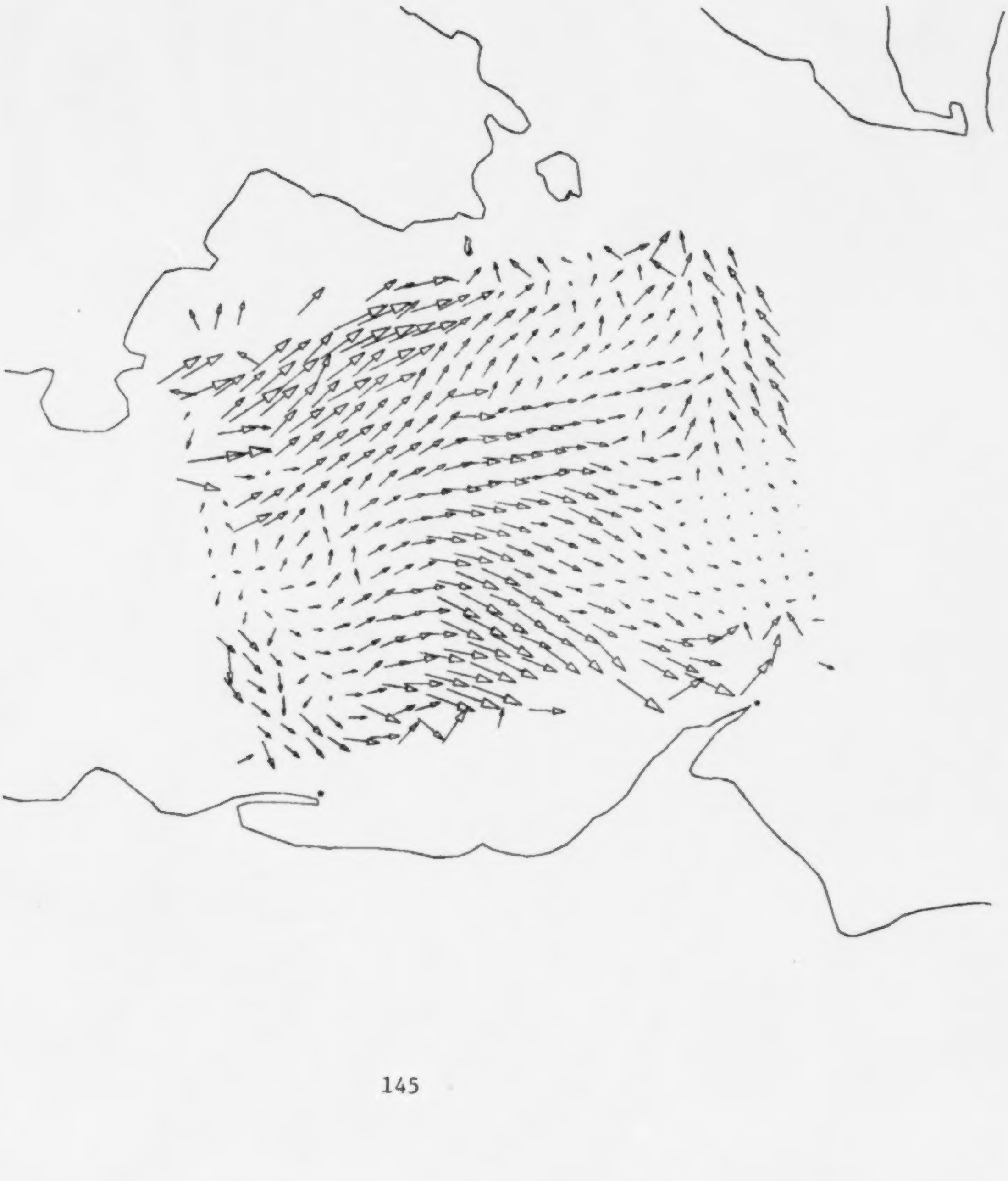
A 2.21



27 AUG 78 11: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

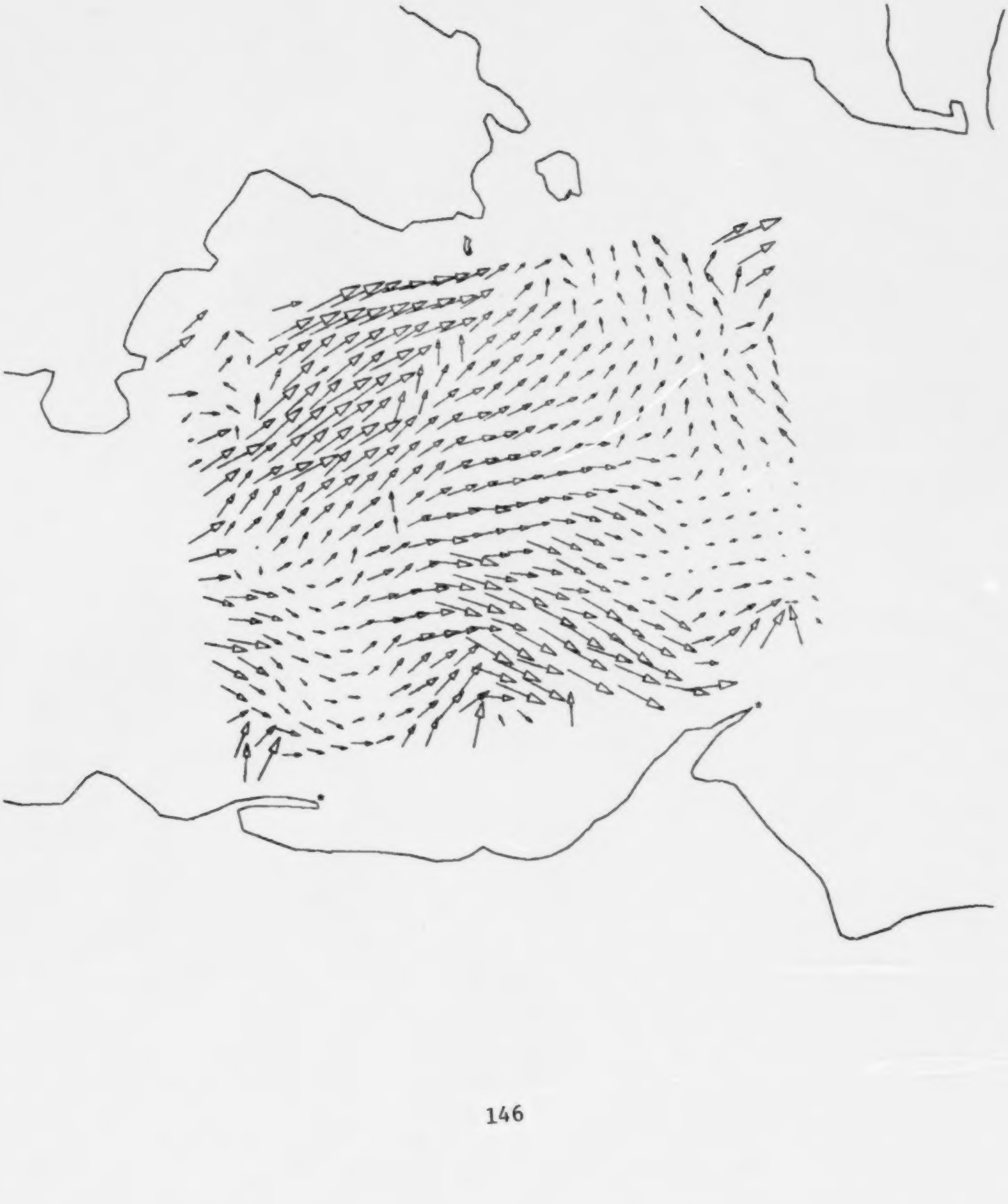
A 2.22



27 AUG 78 12: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

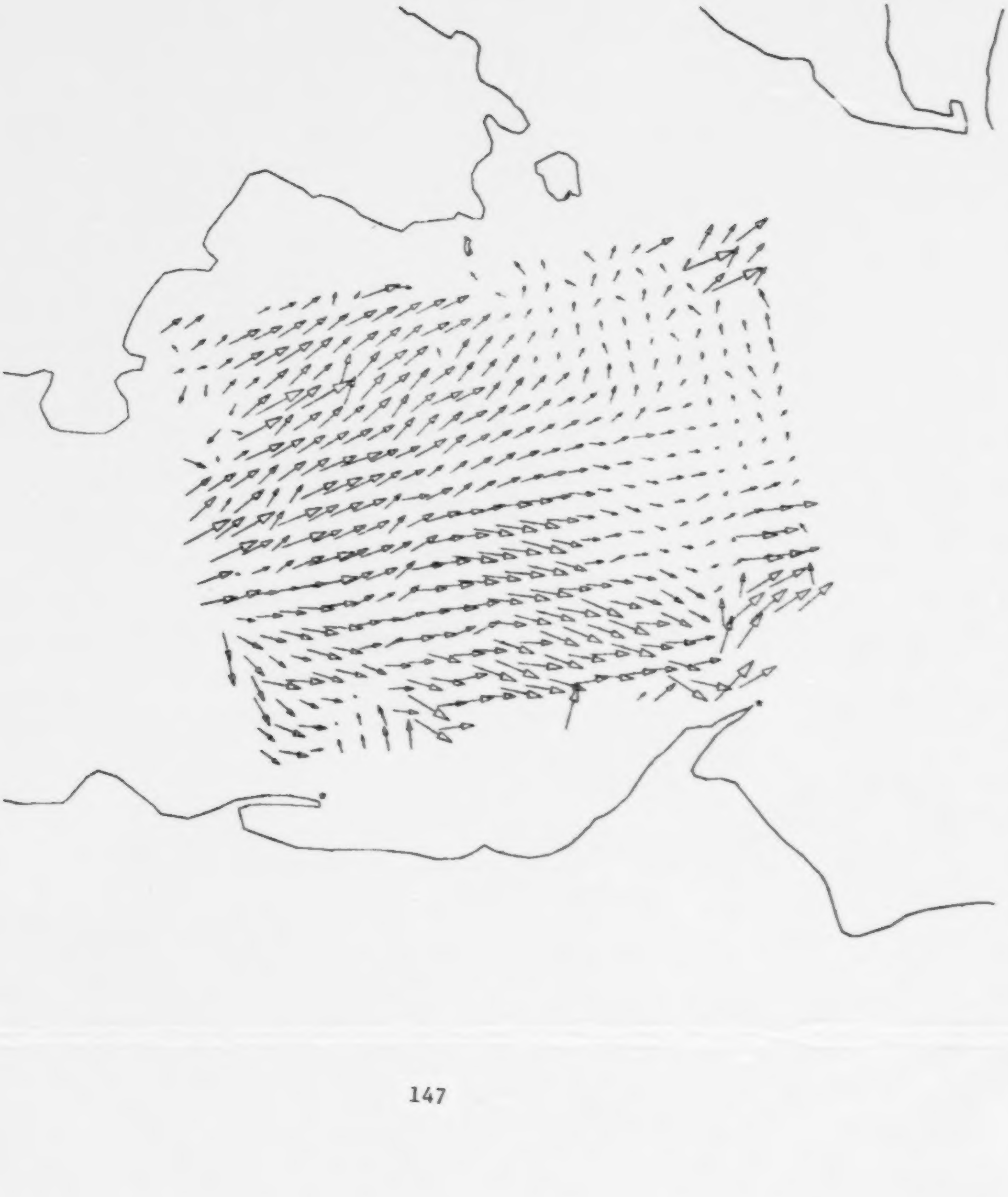
A 2.23



27 AUG 78 13: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [――――――]
200 CM/S [――――――]
TRUE NORTH ↑

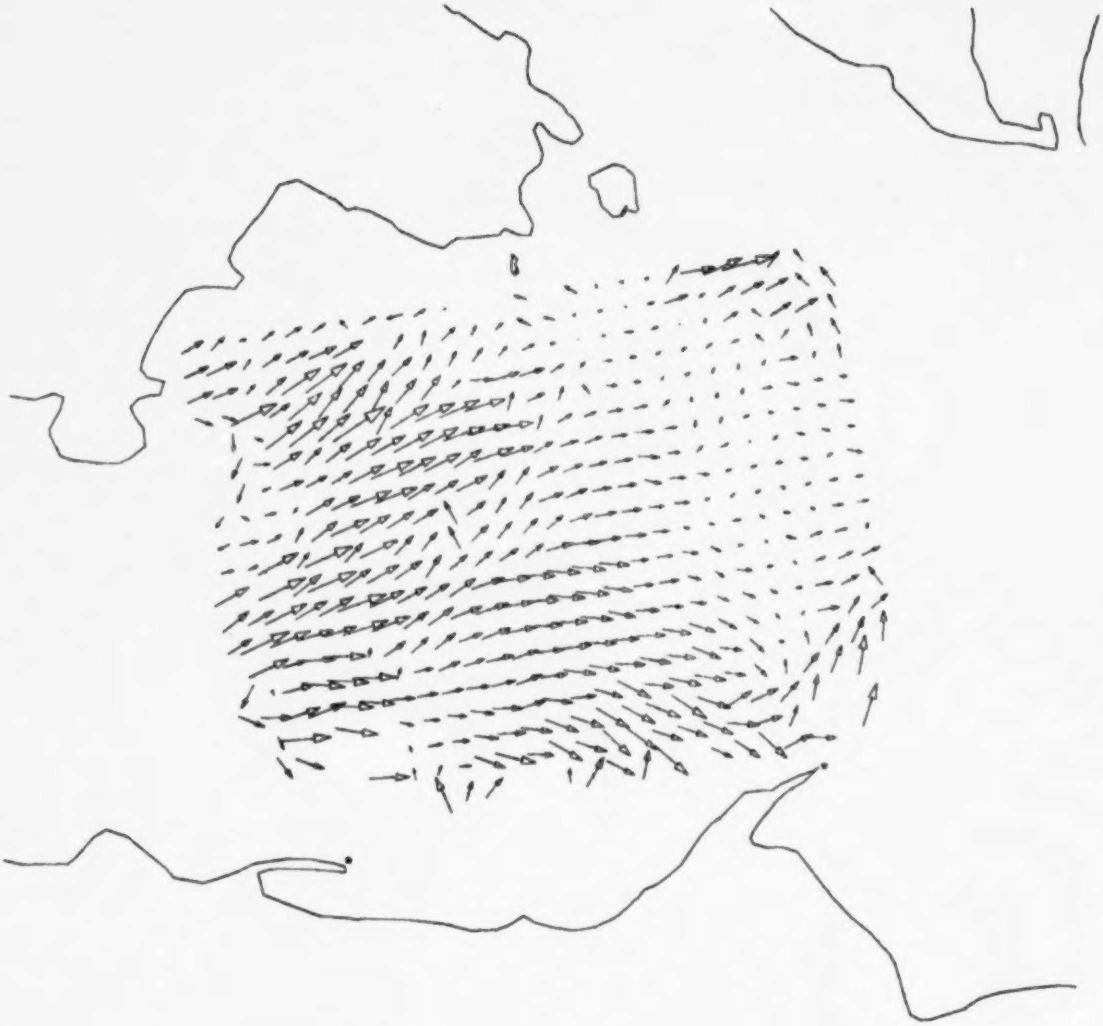
A 2.24



27 AUG 78 14: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [---------------]
200 CM/S [---------------]
TRUE NORTH ↑

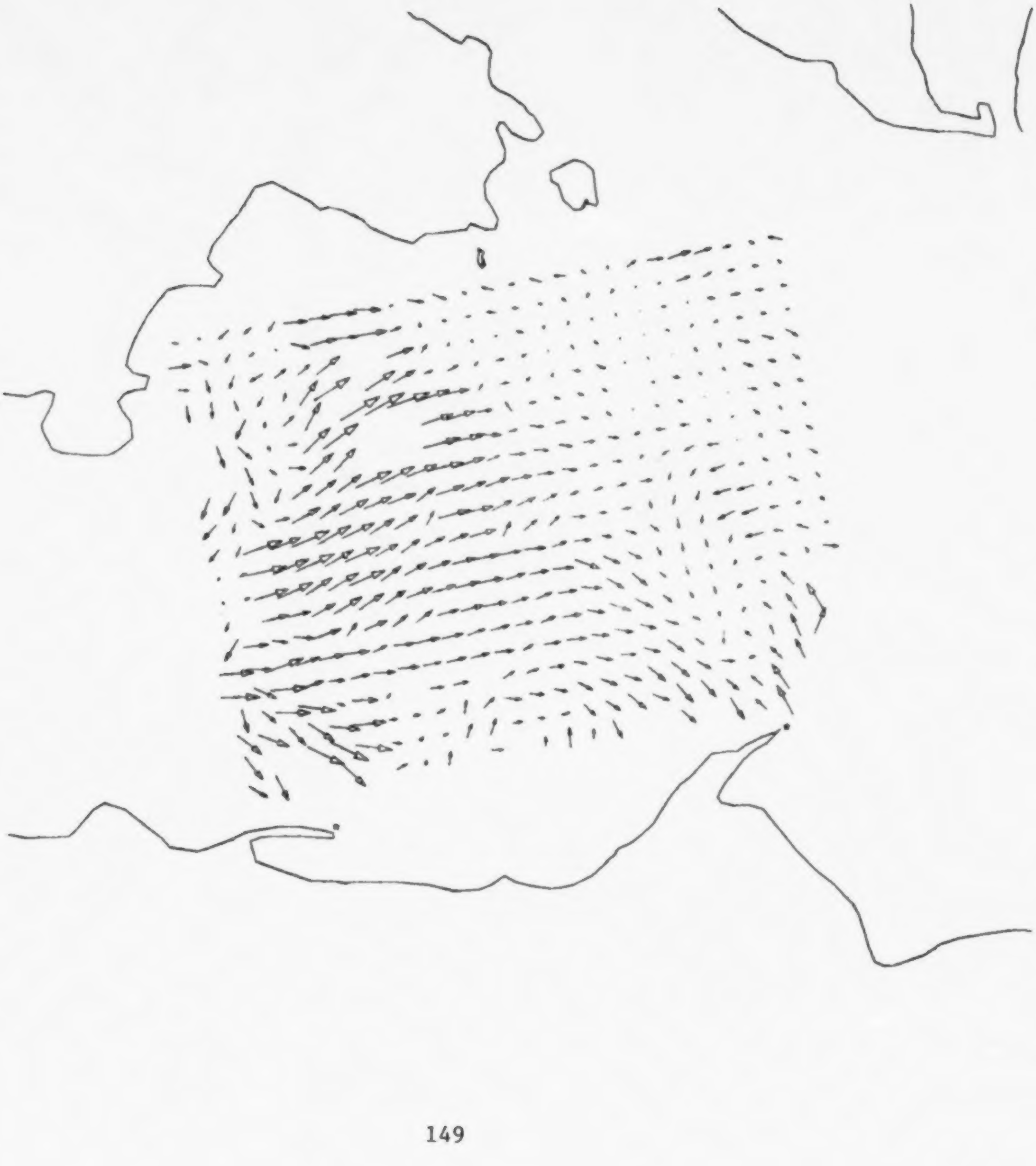
A 2.25



27 AUG 78 15: 0:00
EDIZ HOOK WASHINGTON
DUNGENESS SPIT WASH

6 KM [—————]
200 CM/S [—————]
TRUE NORTH ↑

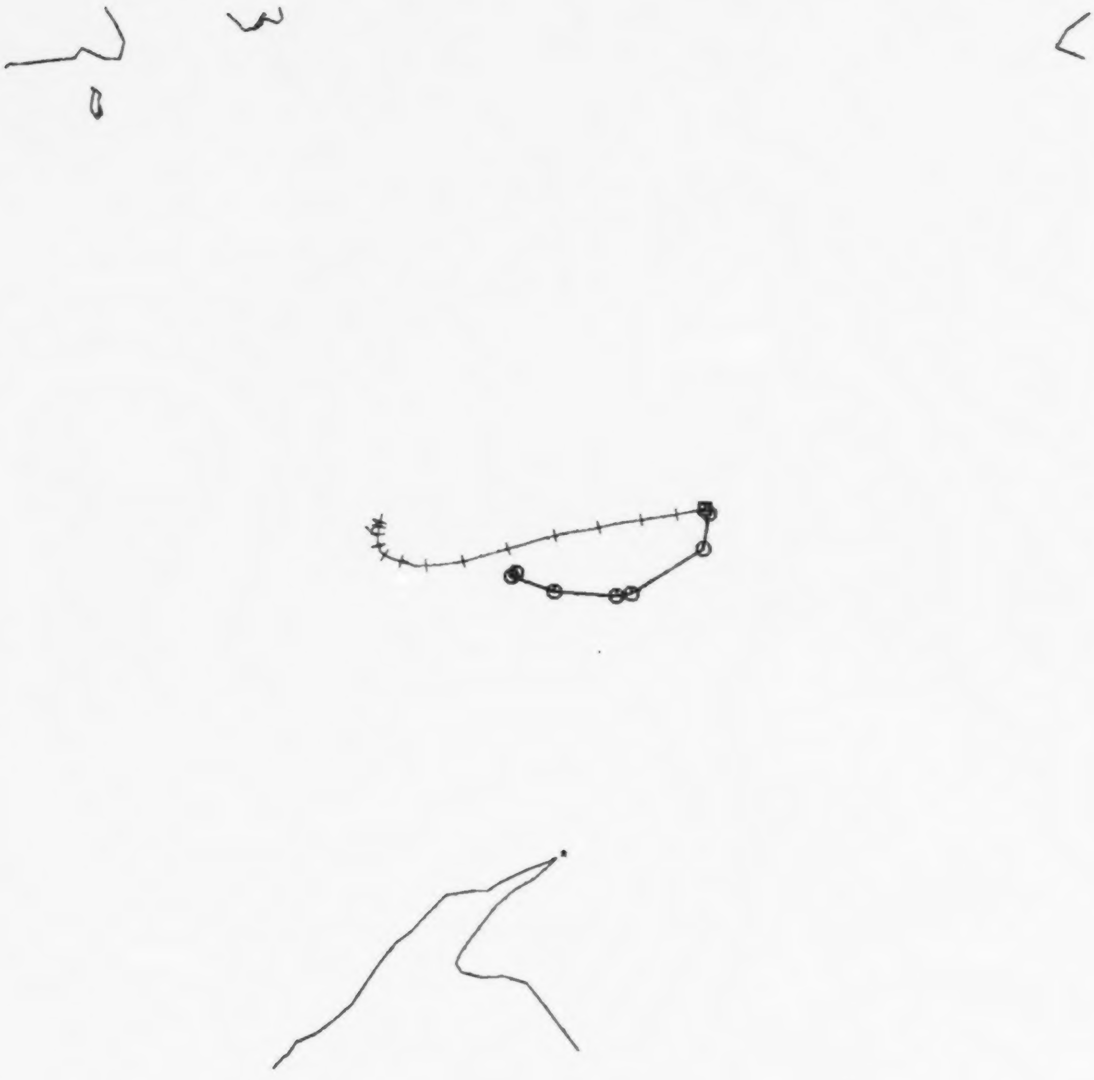
A 2.26



25-AUG-78 11:58:16
25 AUG 78 19:58:16
TID / CO
2005

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

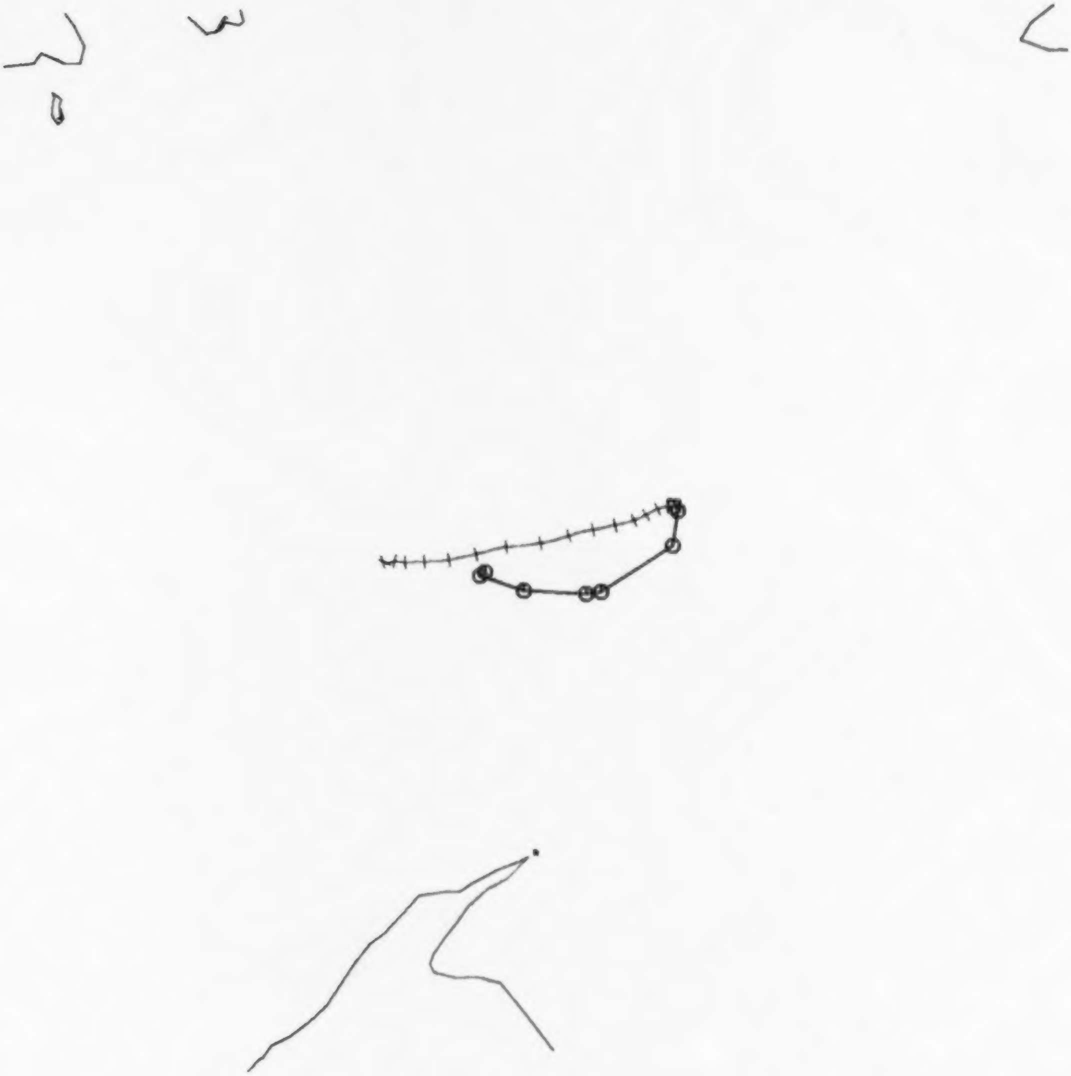
A 3.00



25-AUG-78 11:58:16
25 AUG 78 19:58:16
RAW / CO
2005

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

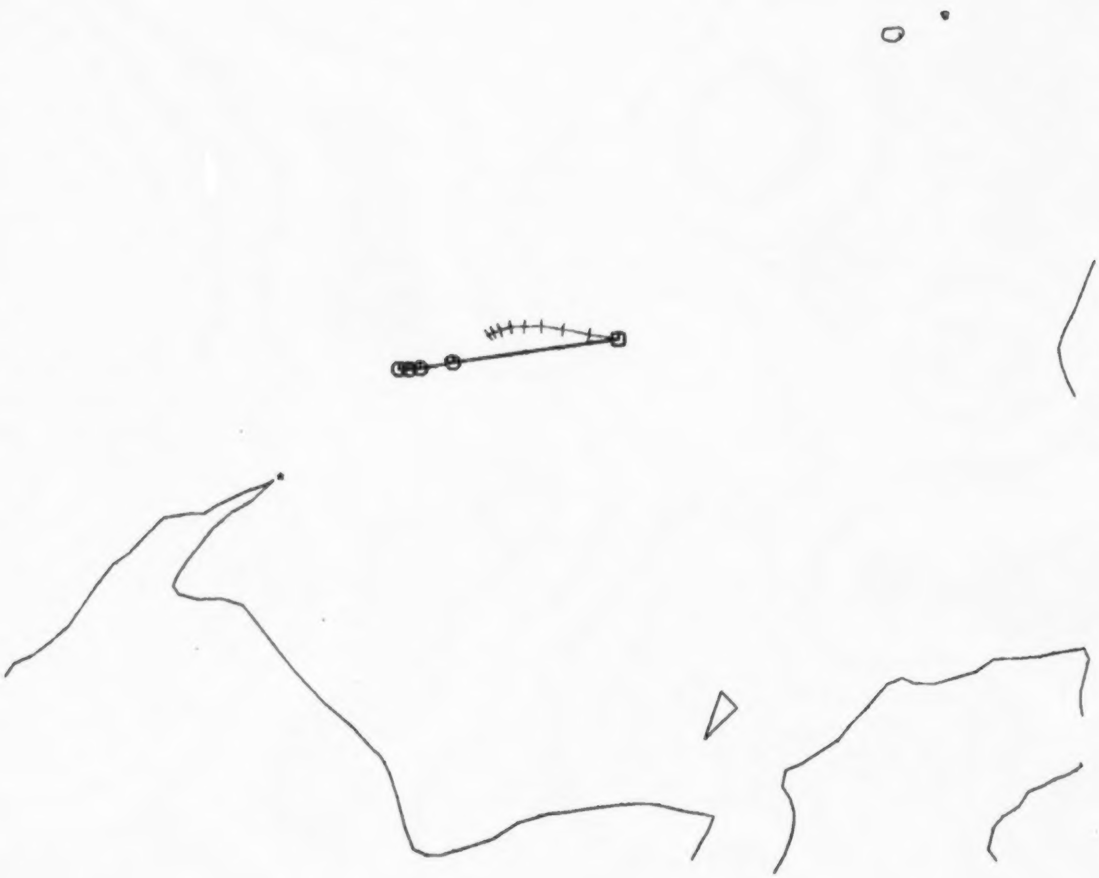
A 3.31



25-AUG-78 13:21:50
25 AUG 78 17:31:50
TIO / C1
1732

4.00 KM [————]
0.50 HR
TRUE NORTH ↑

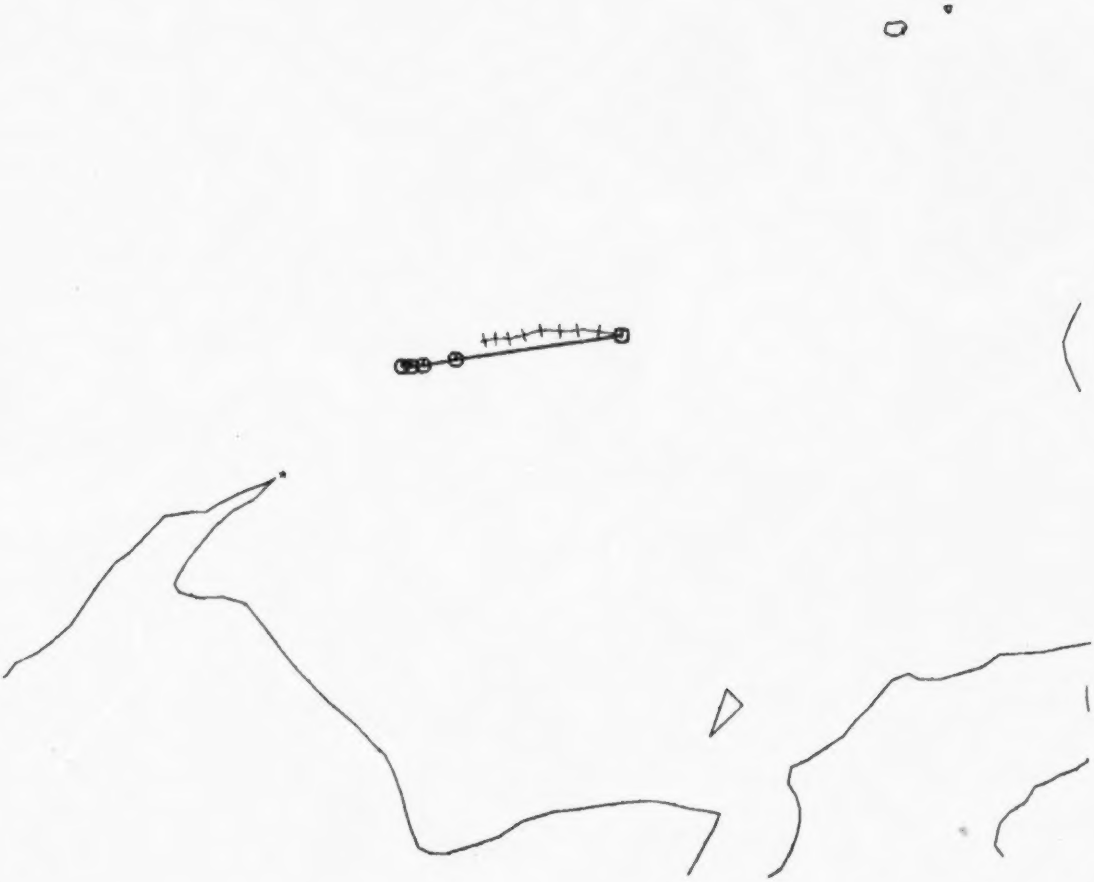
A 3.02



25-AUG-78 13:21:50
25 AUG 78 17:31:50
RAW / C1
1732

4.00 KM [———————]
0.50 HR
TRUE NORTH ↑

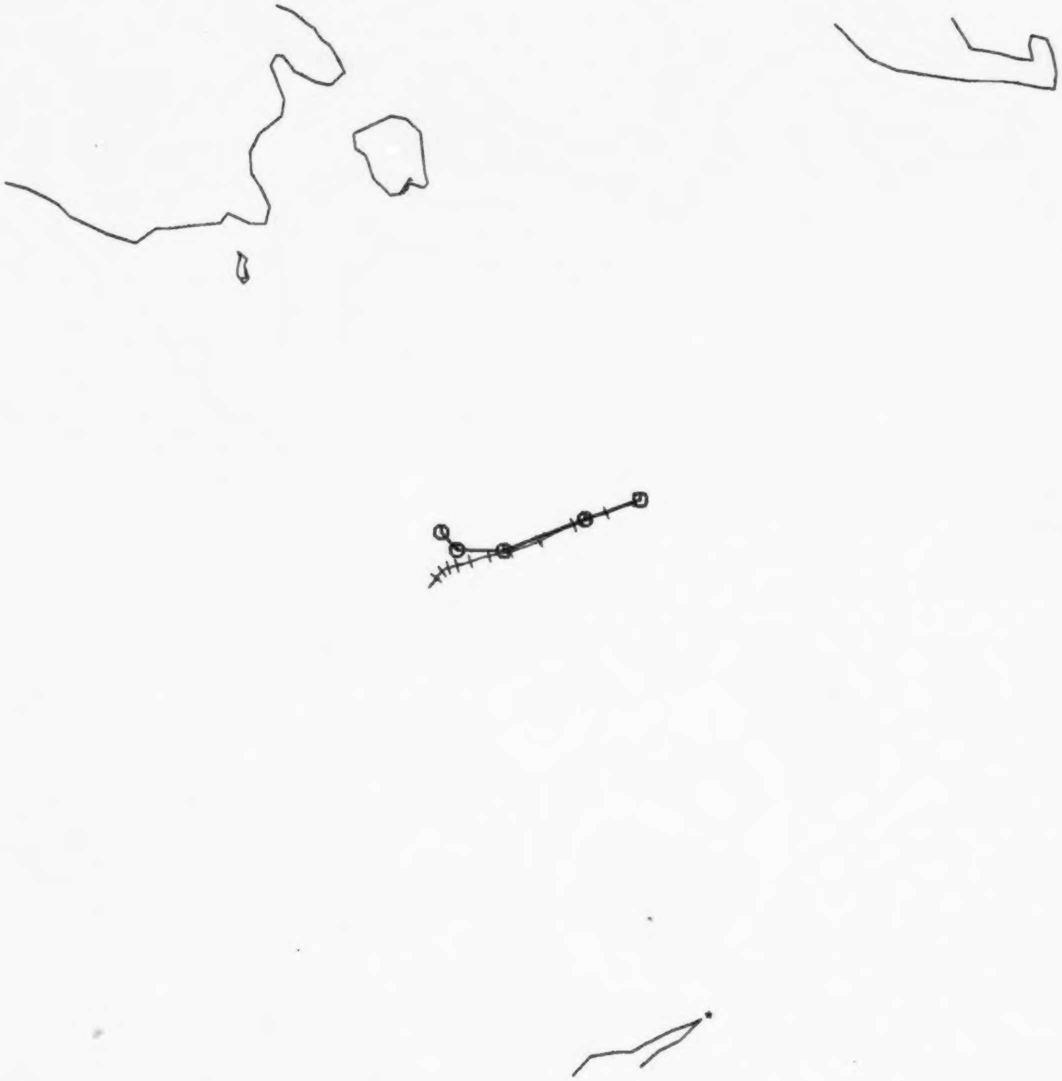
A 3.03



25-AUG-78 12:25:30
25 AUG 78 17:55:30
TID / C2
1803

4.00 KM [ ]
0.50 HR
TRUE NORTH ↑

A 3.04



25-AUG-78 12:25:30
25 AUG 78 17:55:30
RAW / C2
1803

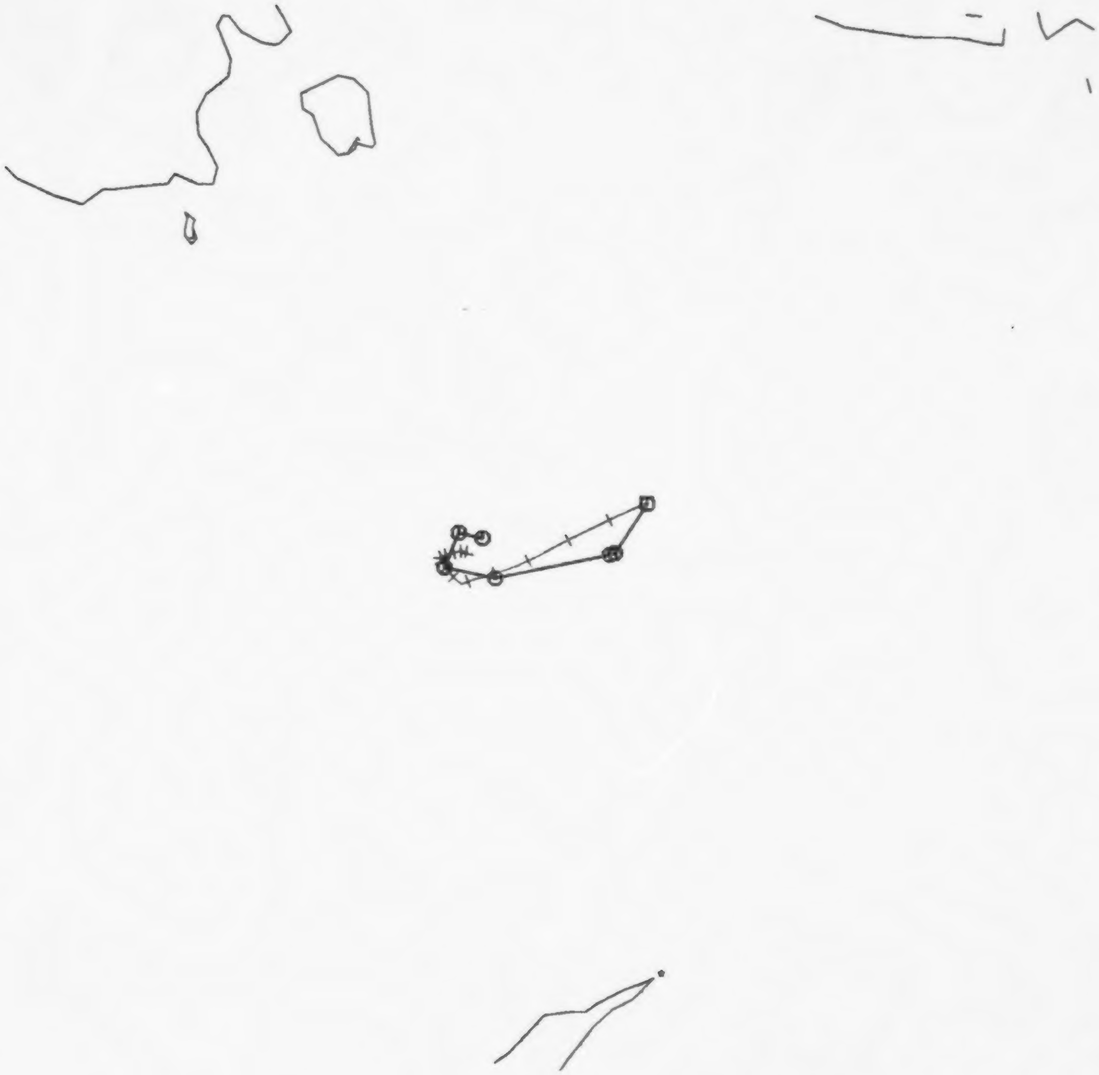
4.00 KM [————]
0.50 HR
TRUE NORTH ↑

A 3.05

25-AUG-78 12:27:40
25 AUG 78 20: 7:40
TID / C3
2012

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

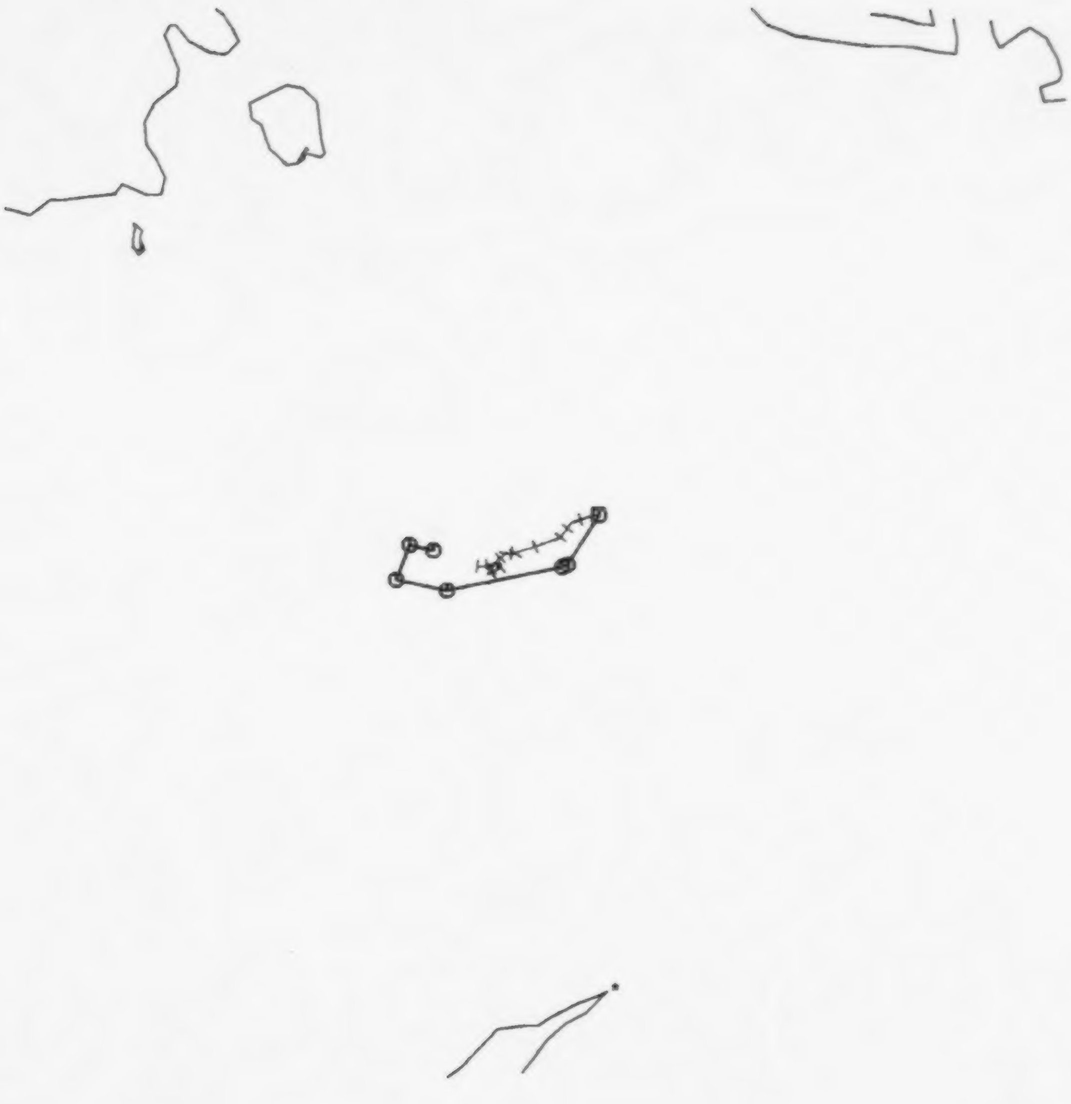
A 3.06



25-AUG-78 12:27:40
25 AUG 78 19:57:40
RAW / C3
2012

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

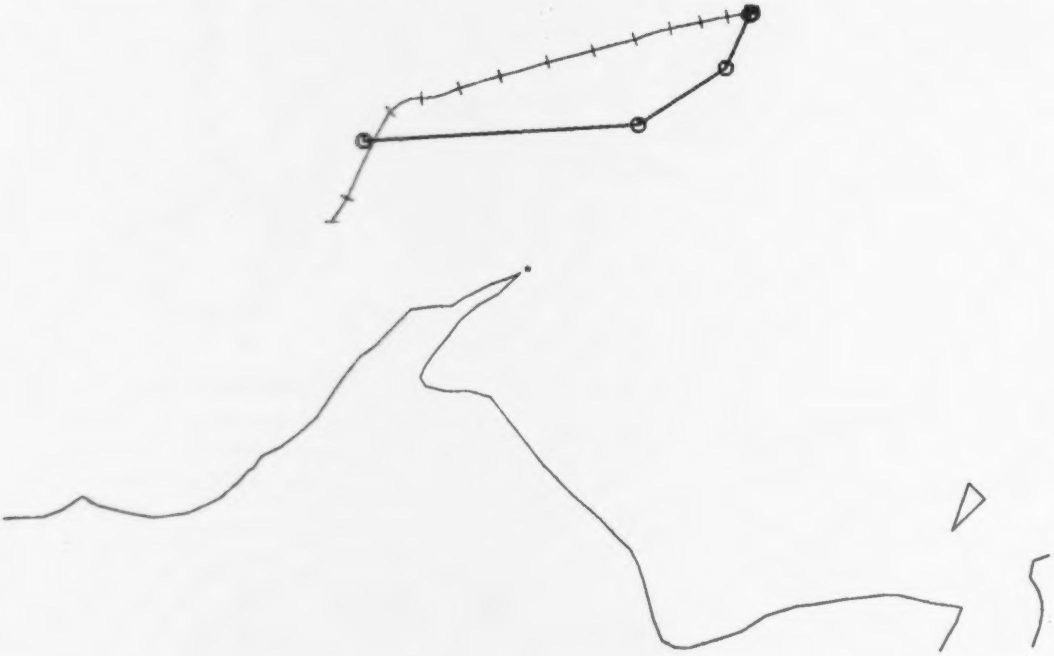
A 3.07



25-AUG-78 12:06:58
25 AUG 78 19:26:58
TID / C4
1934

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

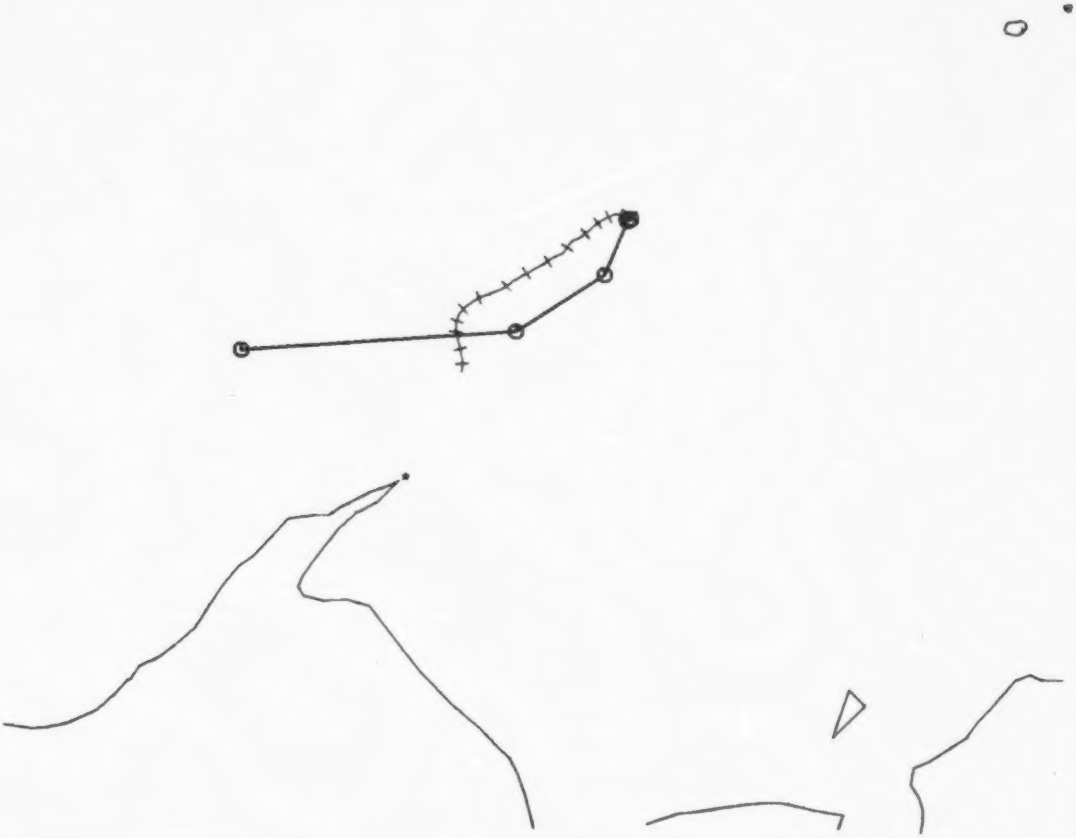
A 3.08



25-AUG-78 12:06:58
25 AUG 78 19:26:58
RAW / C4
1934

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

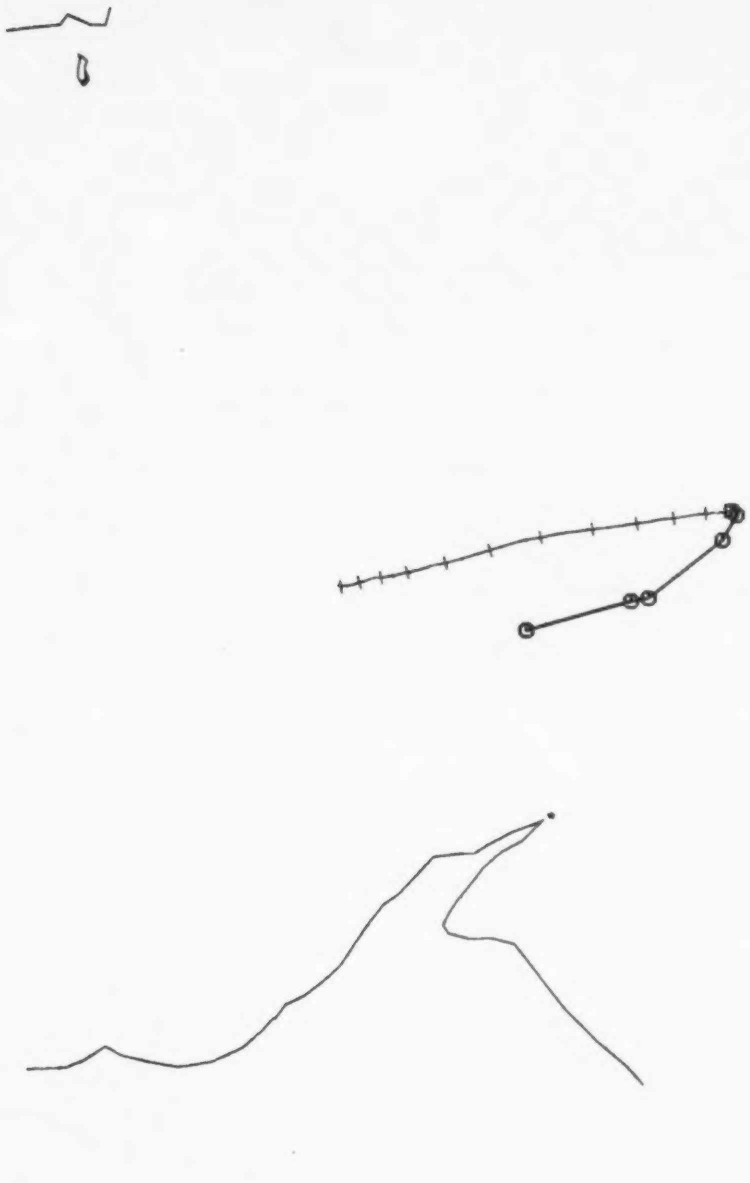
A 3.09



25-AUG-78 12:10:35
25 AUG 78 17:50:35
TID / CS
1752

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

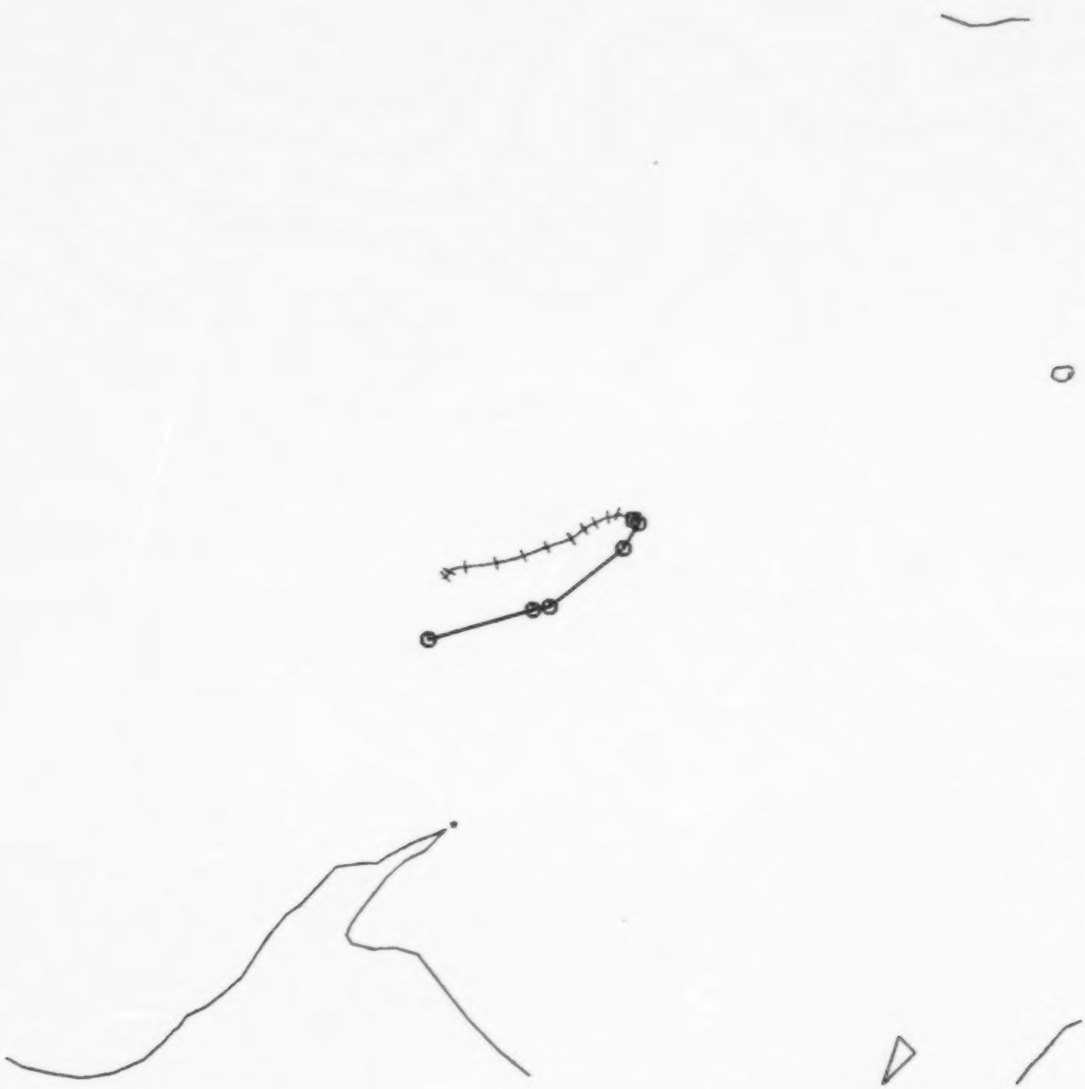
A 3.10



25-AUG-78 12:10:35
25 AUG 78 17:50:35
RAW / CS
1752

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

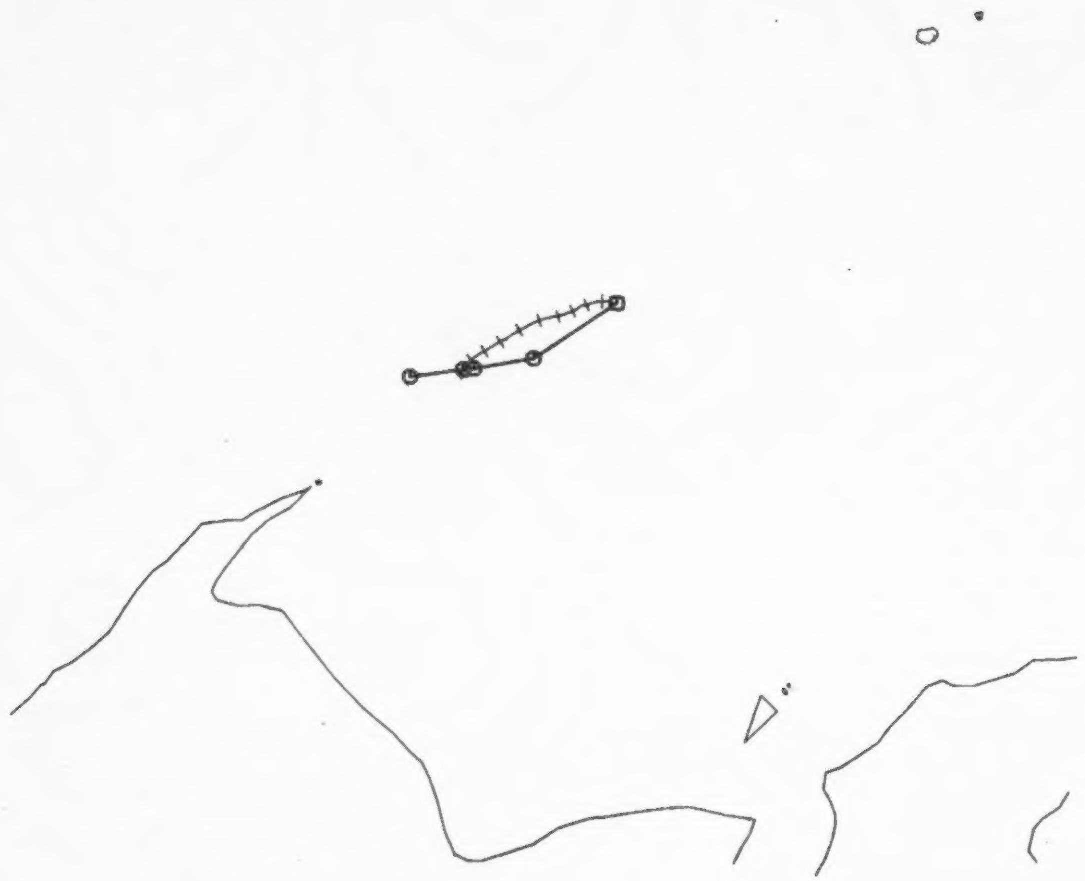
A 3.11



25-AUG-78 12:18:15
25 AUG 78 17:28:15
RAW / C6
1734

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

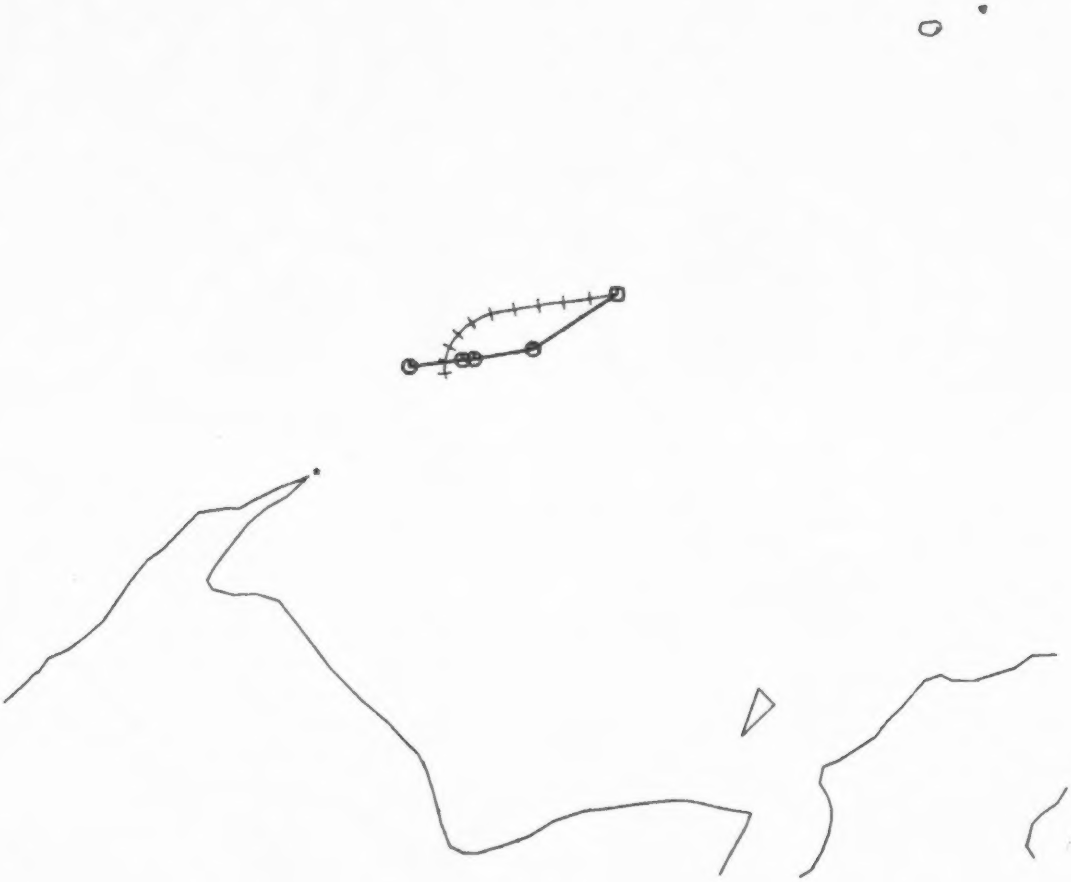
A 3.12



25-AUG-78 12:18:15
25 AUG 78 17:28:15
TID / C6
1734

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

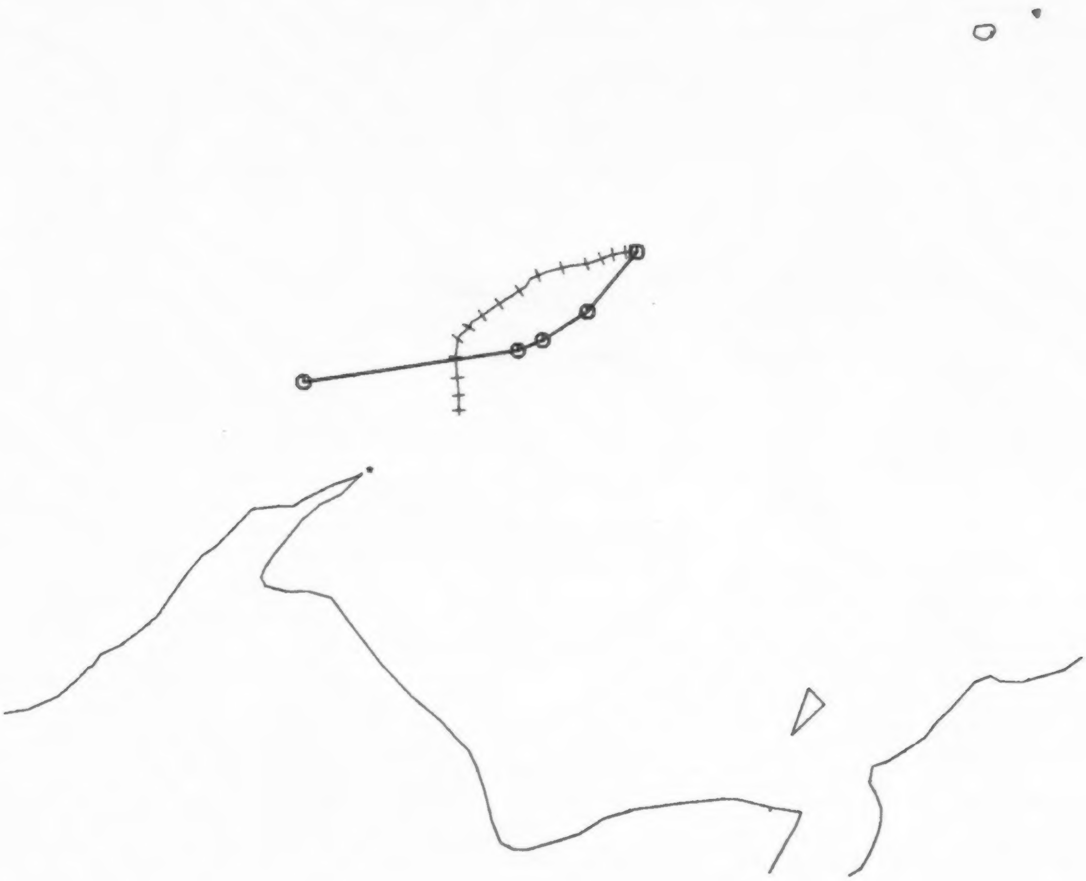
A 3.13



25-AUG-78 12:04:10
25 AUG 78 19:44:10
RAW / C7
1953

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

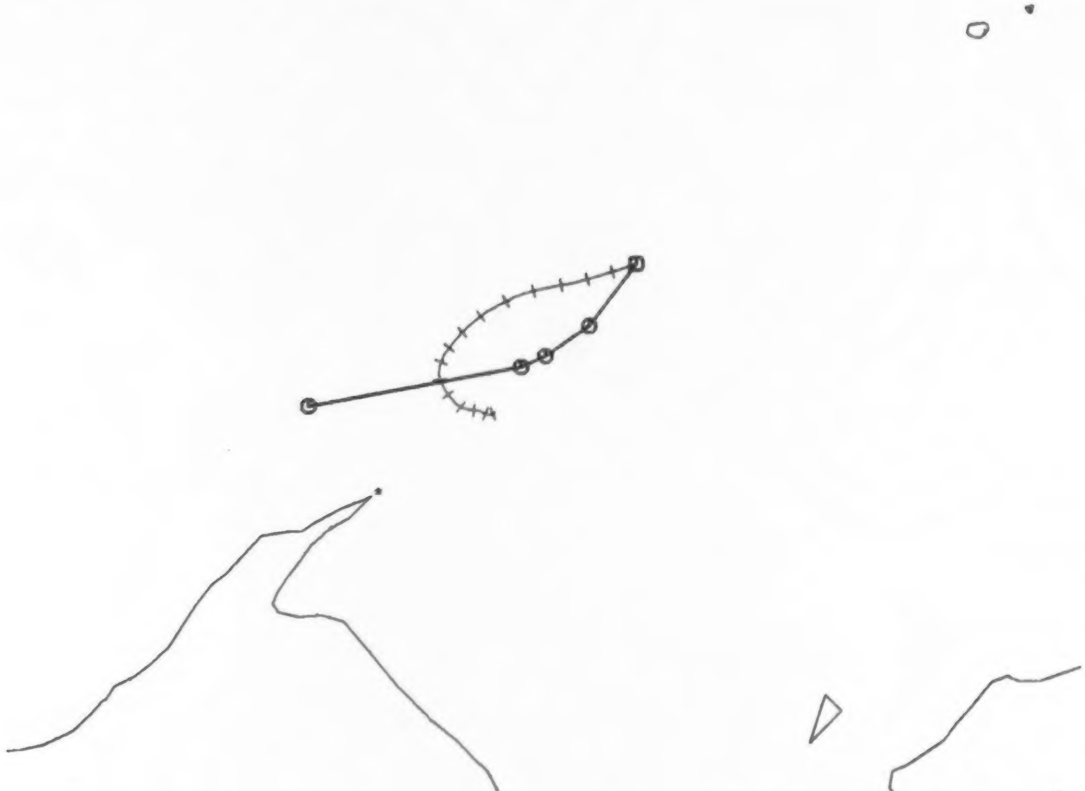
A 3.14



25-AUG-78 12:04:10
25 AUG 78 19:44:10
TID / C7
1953

4.00 KM [------------]
0.50 HR
TRUE NORTH ↑

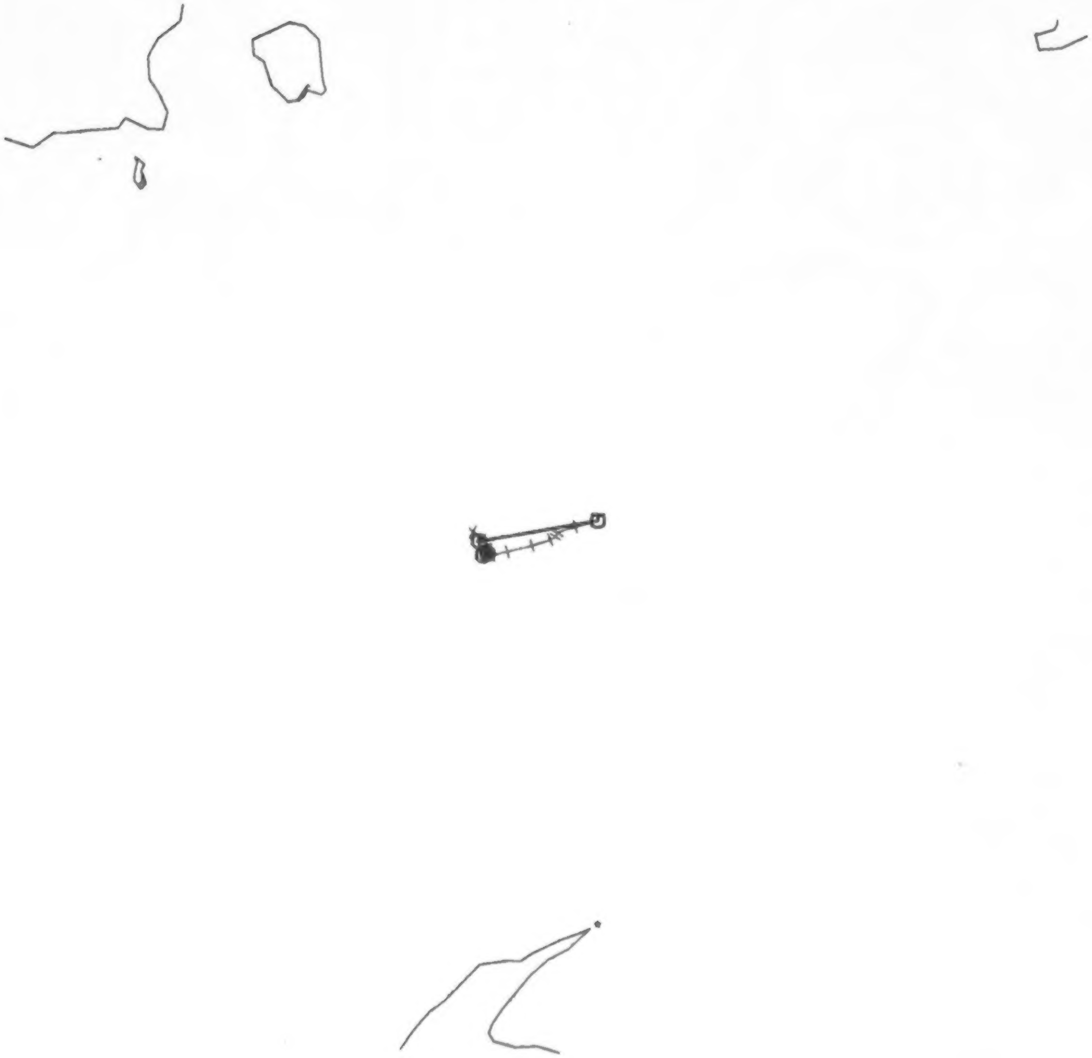
A 3.15



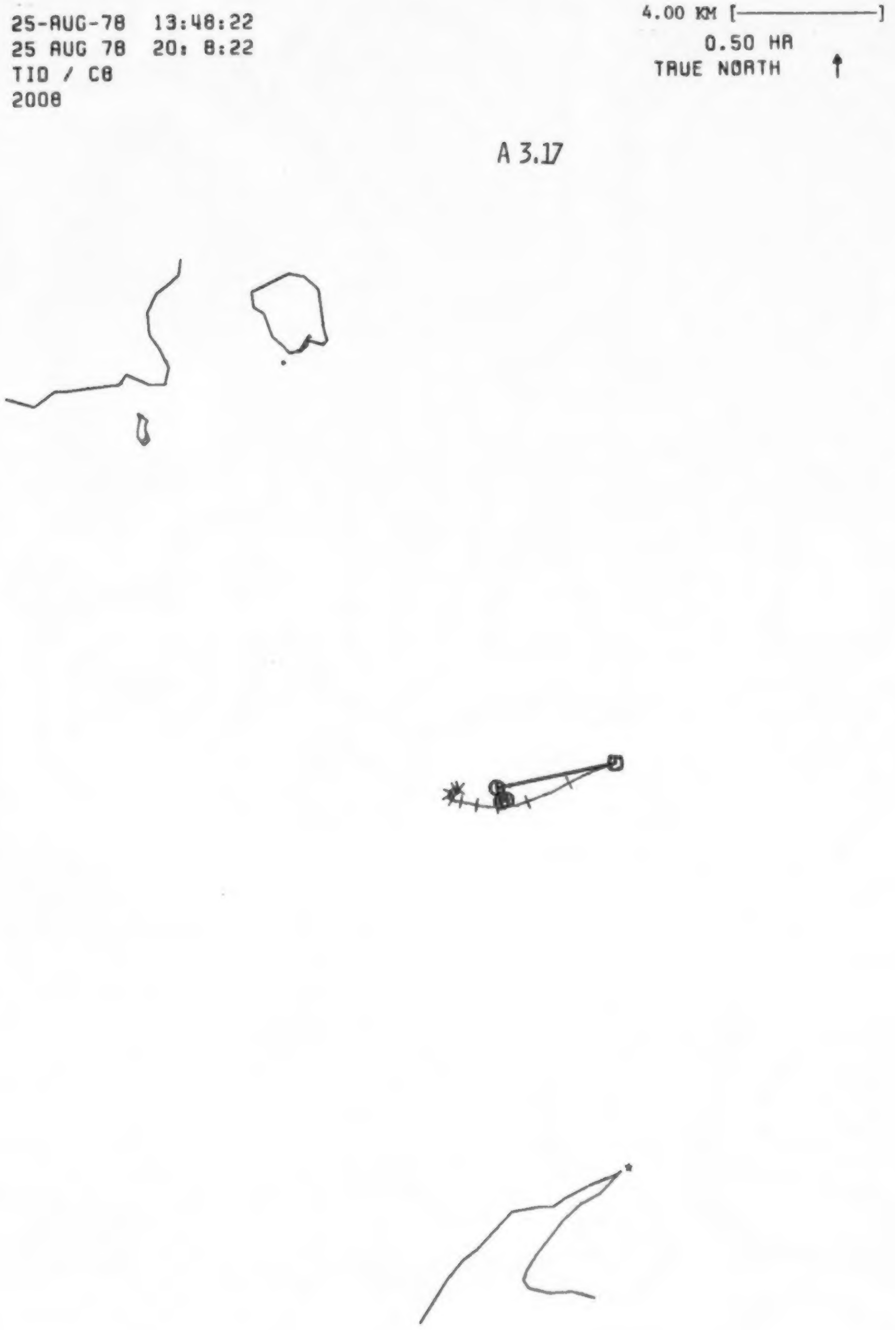
25-AUG-78 13:48:22
25 AUG 78 20: 8:22
RAW / C8
2008

4.00 KM [———————]
0.50 HR
TRUE NORTH ↑

A 3.16



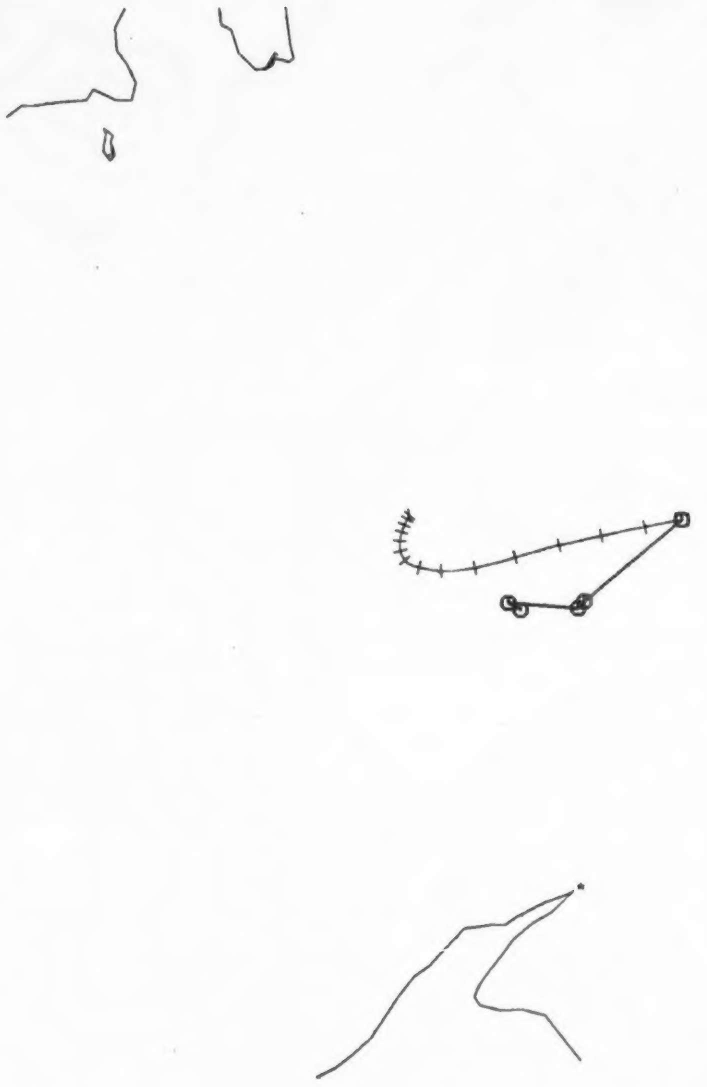
A 3.17


25-AUG-78 13:48:22
25 AUG 78 20: 8:22
TID / C8
2008
4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

25-AUG-78 12:31:12
25 AUG 78 20: 1:12
TID / C9
2002

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

A 3.18



25-AUG-78 12:31:12
25 AUG 78 20: 1:12
RAW / C9
2002

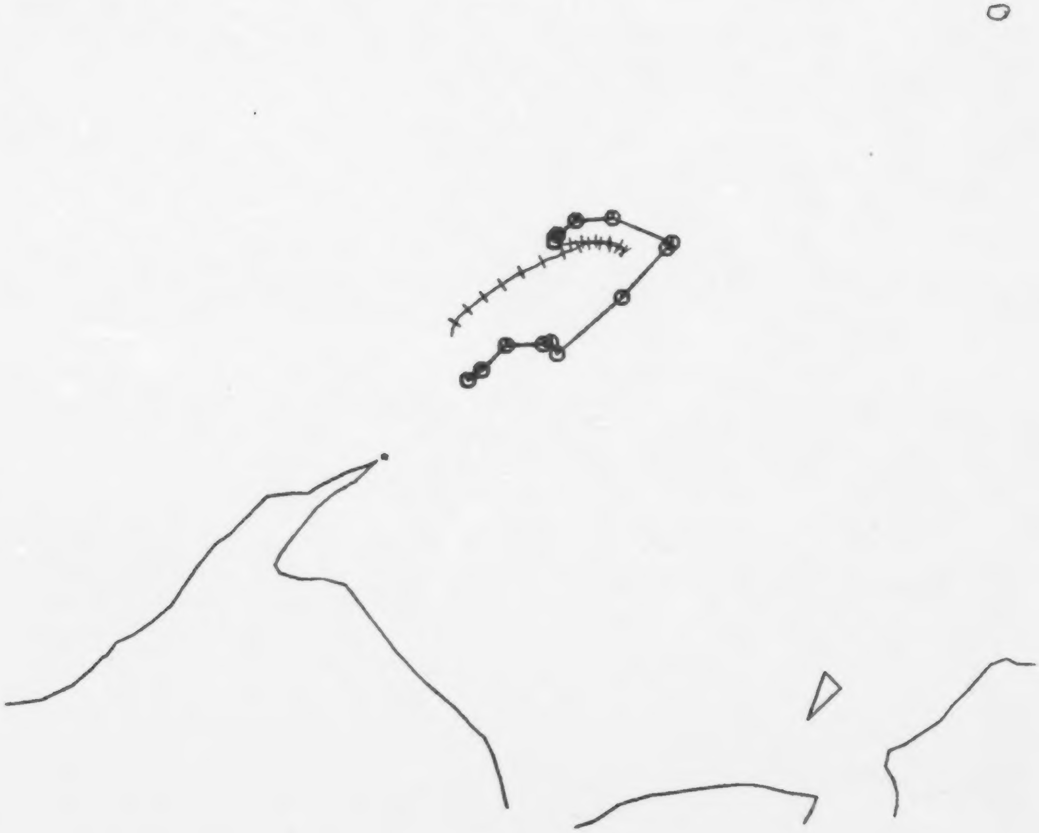
4.00 KM [--------------]
0.50 HR
TRUE NORTH ↑

A 3.19

25-AUG-78 07:07:15
25 AUG 78 17:27:15
RAW / X6
1733

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

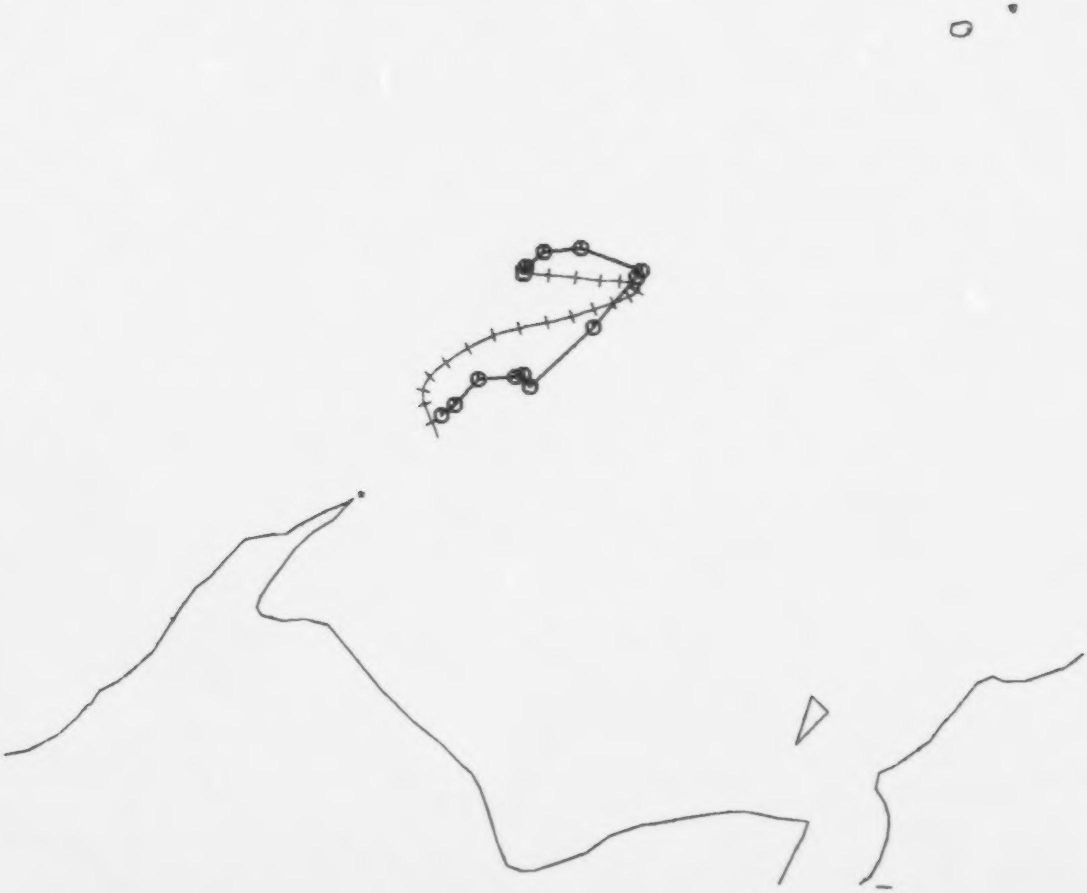
A 3.20



25-AUG-78 07:07:15
25 AUG 78 17:27:15
TID / X6
1733

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

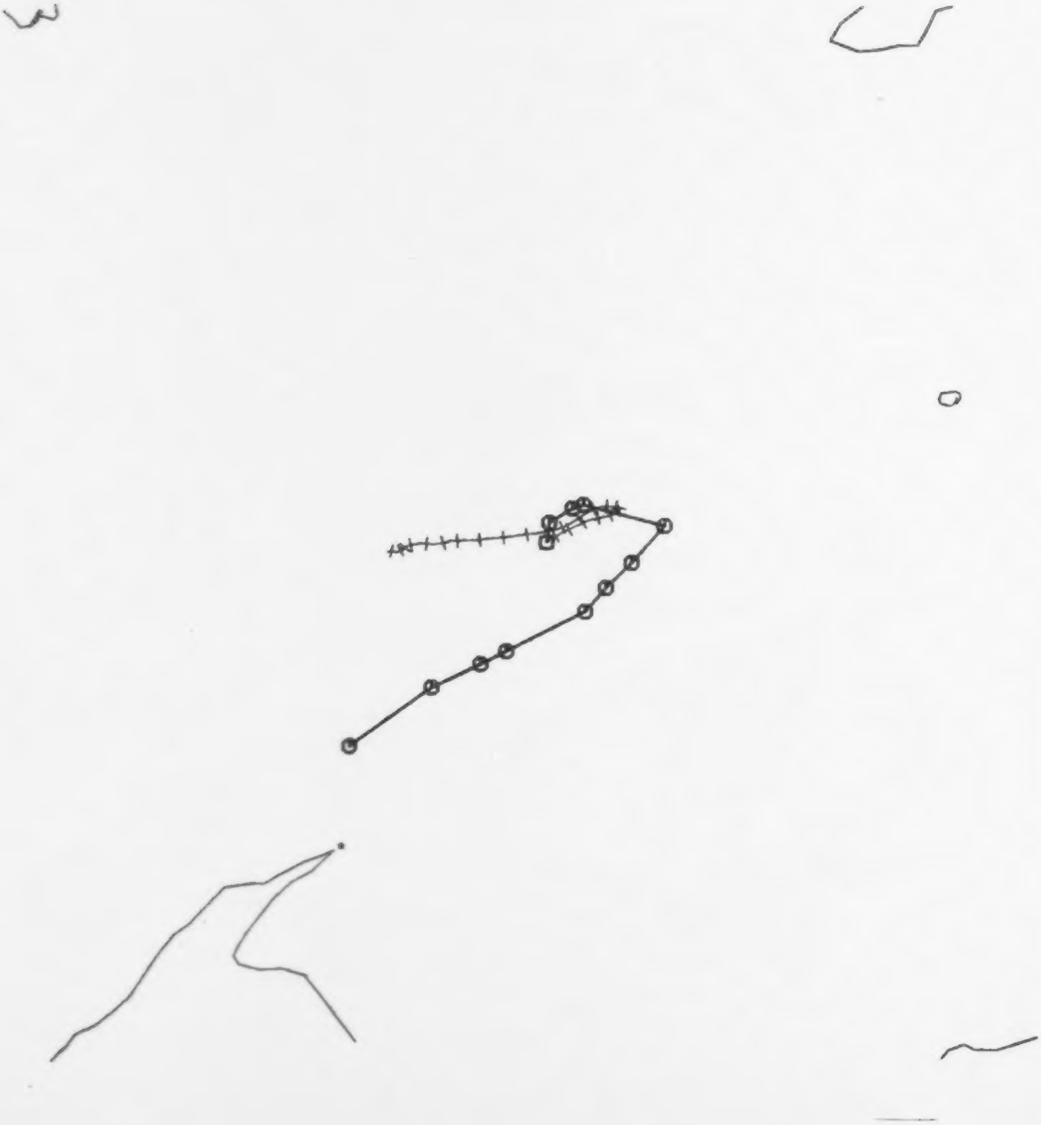
A 3.21



25-AUG-78 07:27:55
25 AUG 78 19:47:55
RAW / X7
1955

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

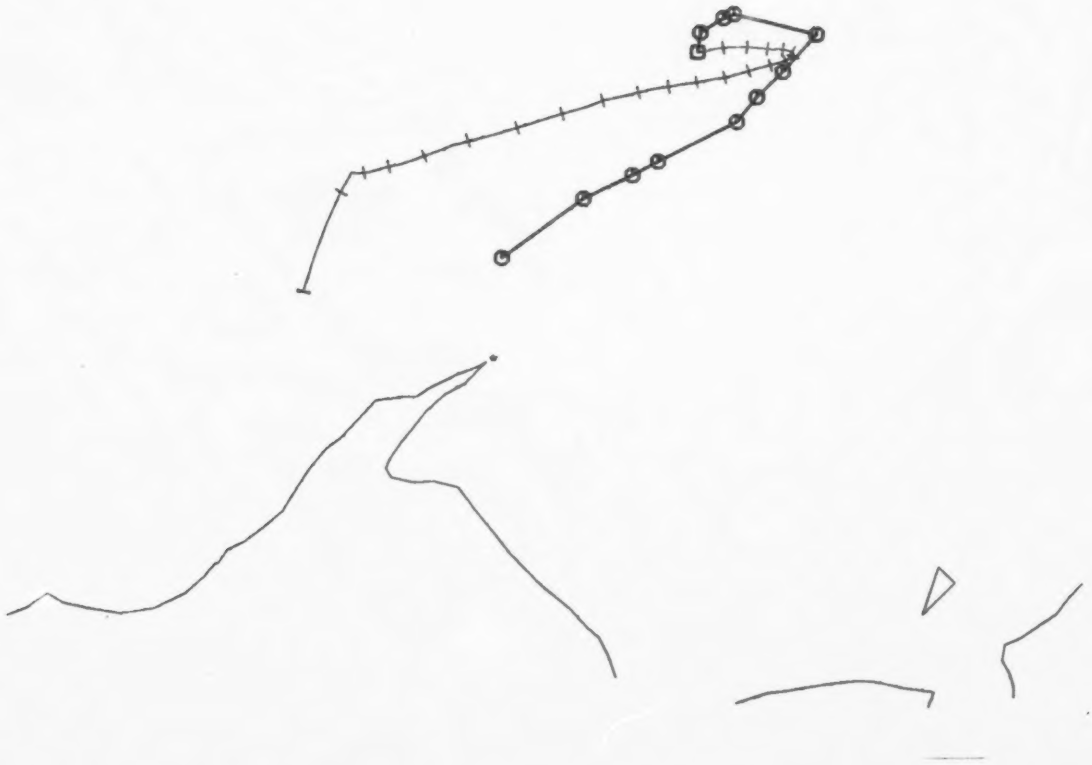
A 3.22



25-AUG-78 07:27:55
25 AUG 78 19:47:55
TID / X7
1955

4.00 KM [—————]
0.50 HR
TRUE NORTH ↑

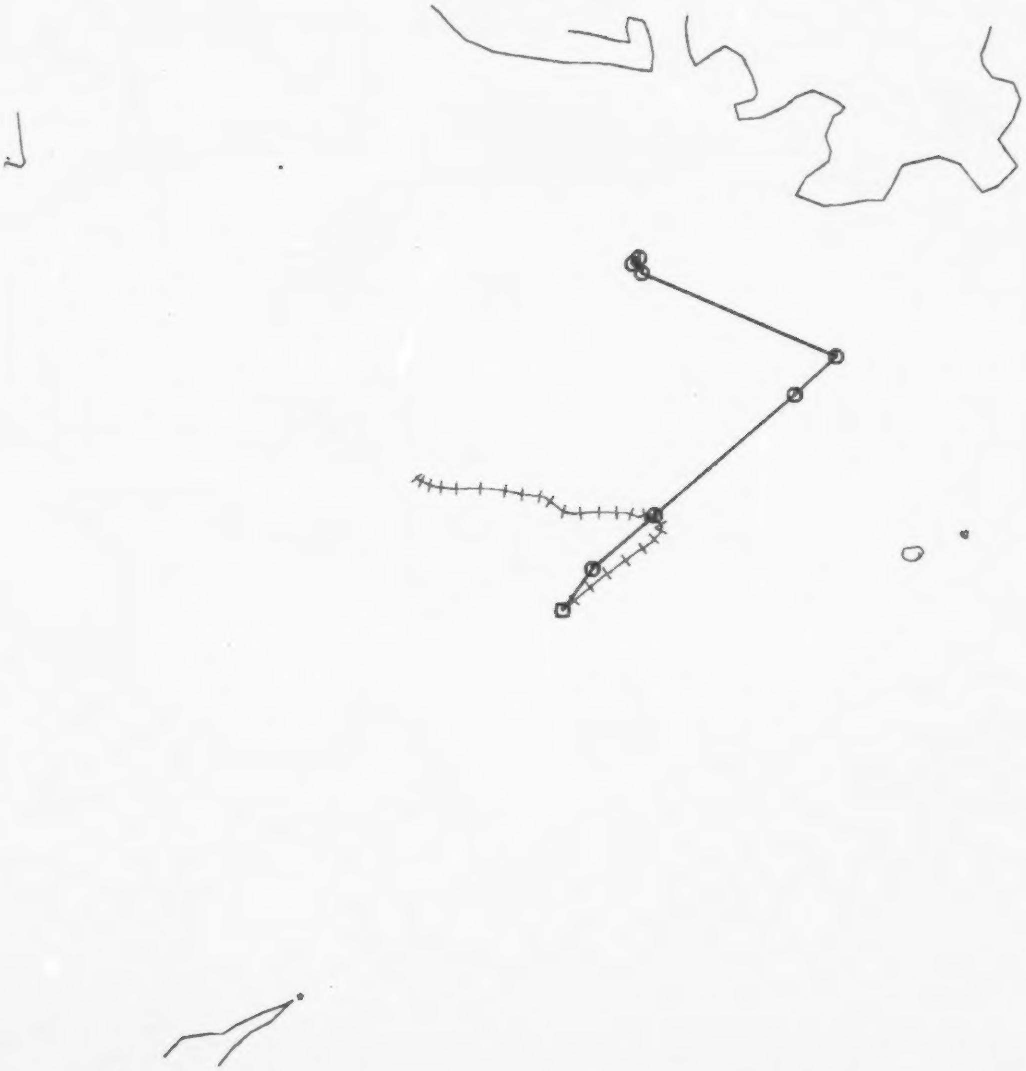
A 3.23



25-AUG-78 07:25:50
25 AUG 78 20:15:50
RAW / X8
2031

4.00 KM [—————————]
0.50 HR
TRUE NORTH ↑

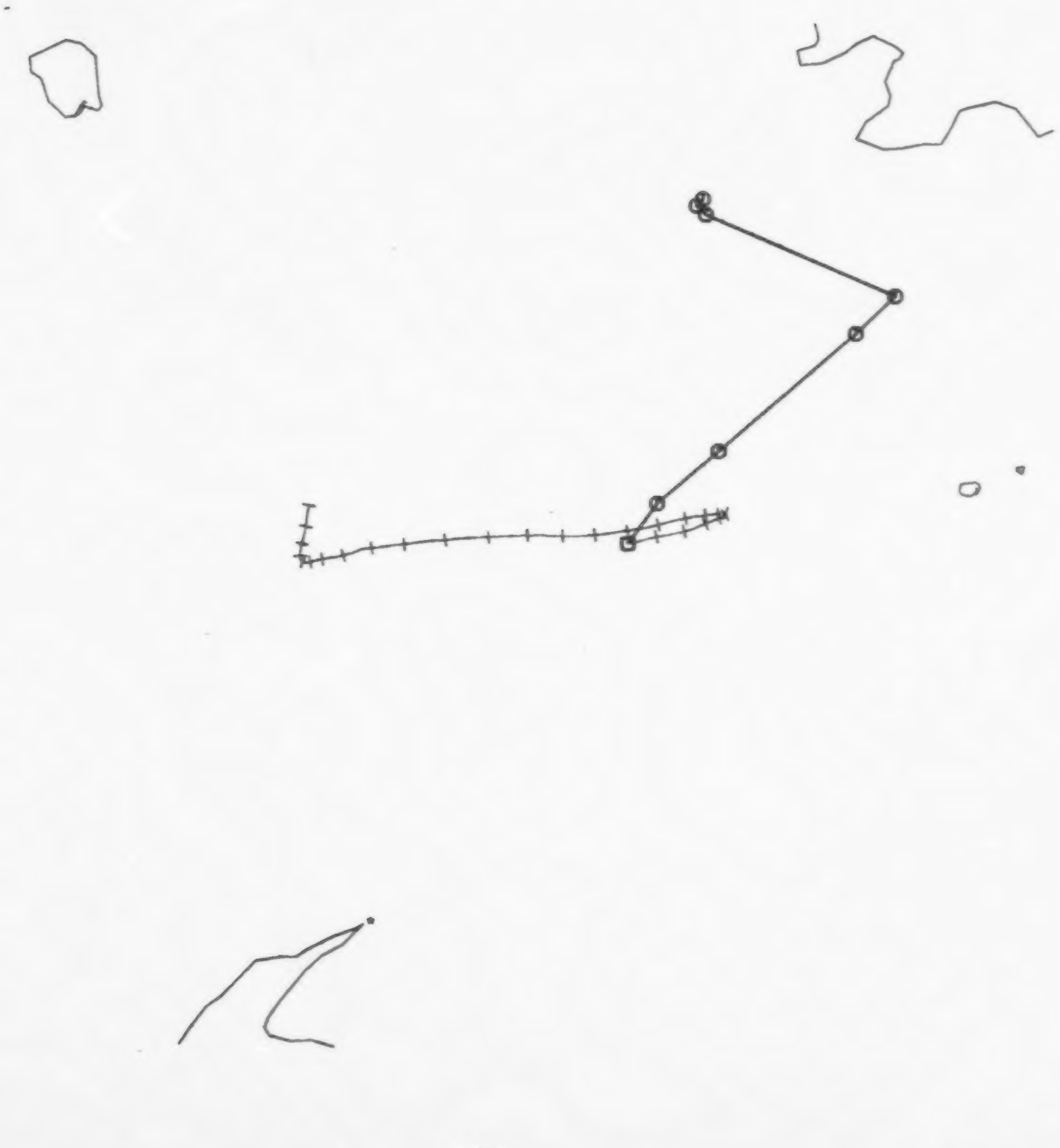
A 3.24



25-AUG-78 07:25:50
25 AUG 78 20:25:50
TID / X8
2031

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

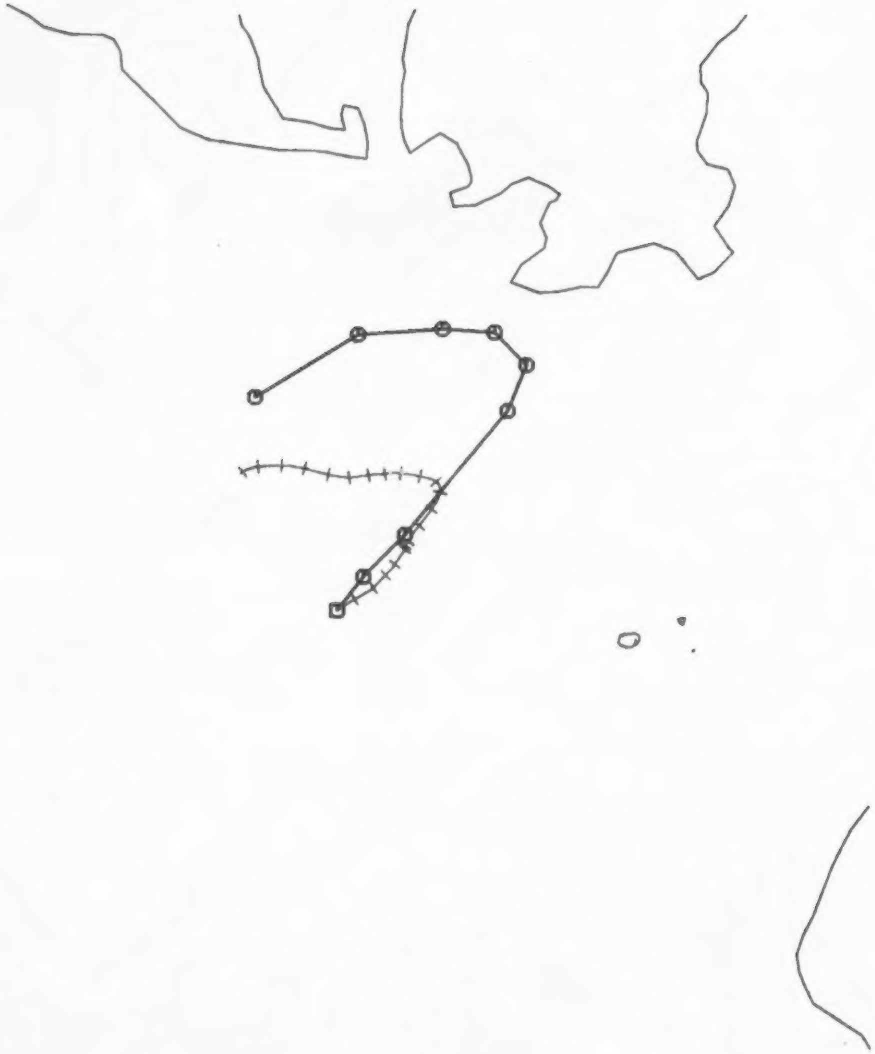
A 3.25



25-AUG-78 07:36:00
25 AUG 78 18:26:00
AAW / X9
1831

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

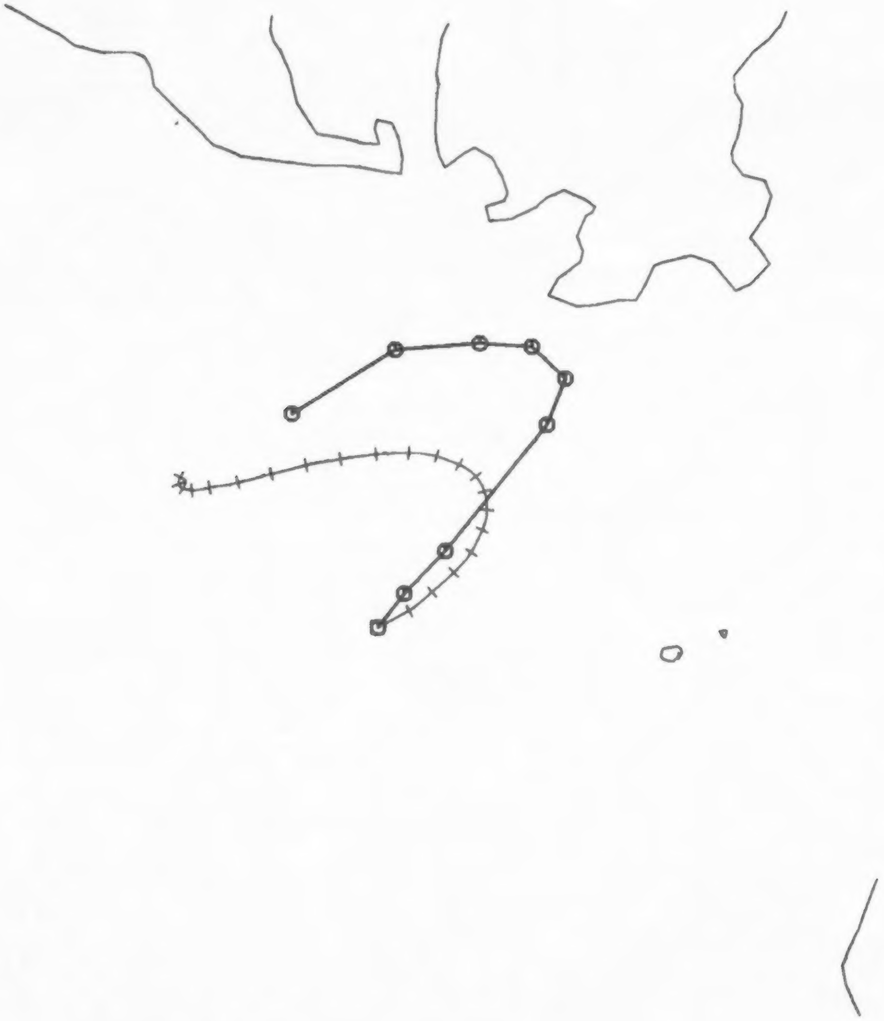
A 3.26



25-AUG-78 07:36:00
25 AUG 78 18:26:00
TID / X9
1831

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

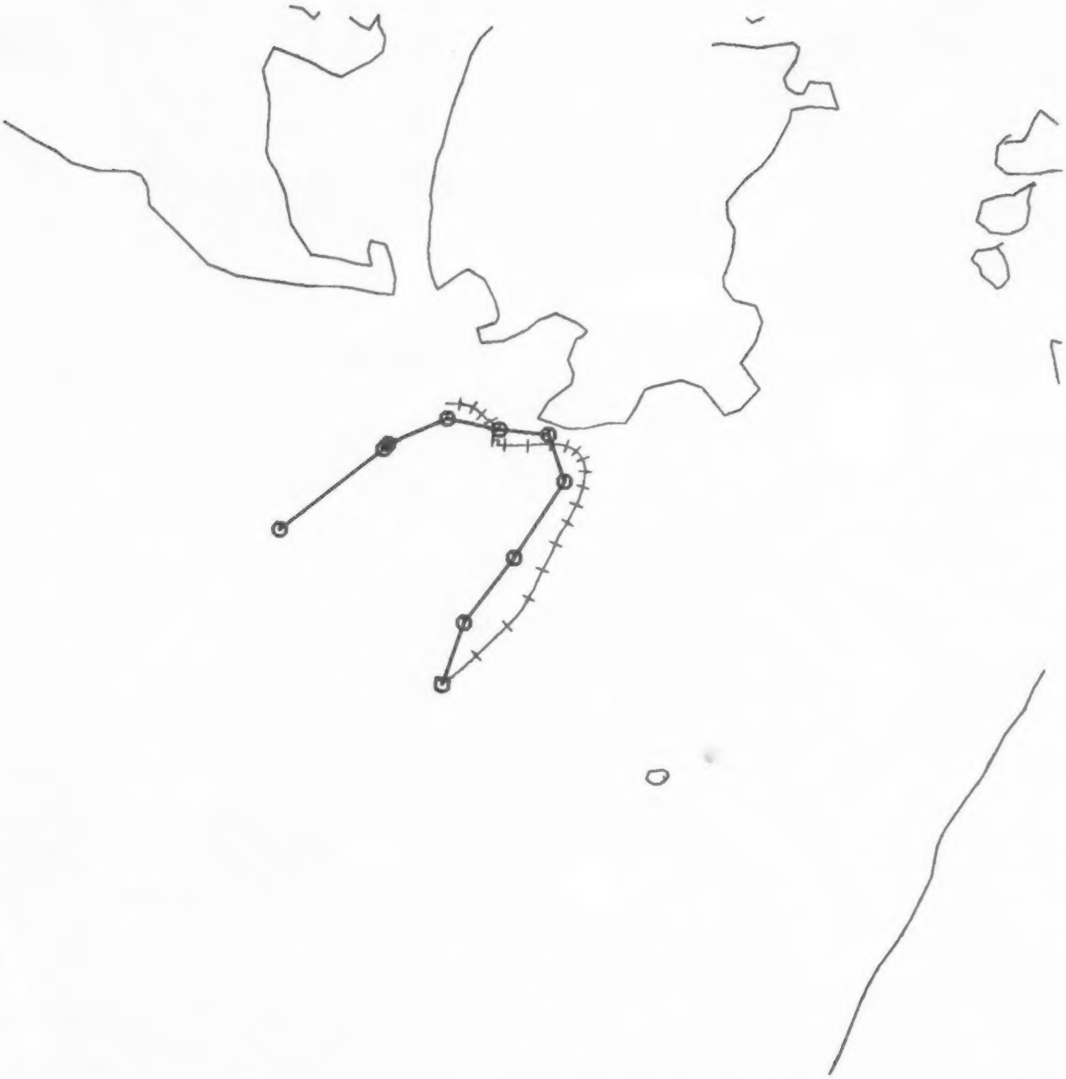
A 3,27



25-AUG-78 07:33:40
25 AUG 78 18:23:40
TID / YO
1830

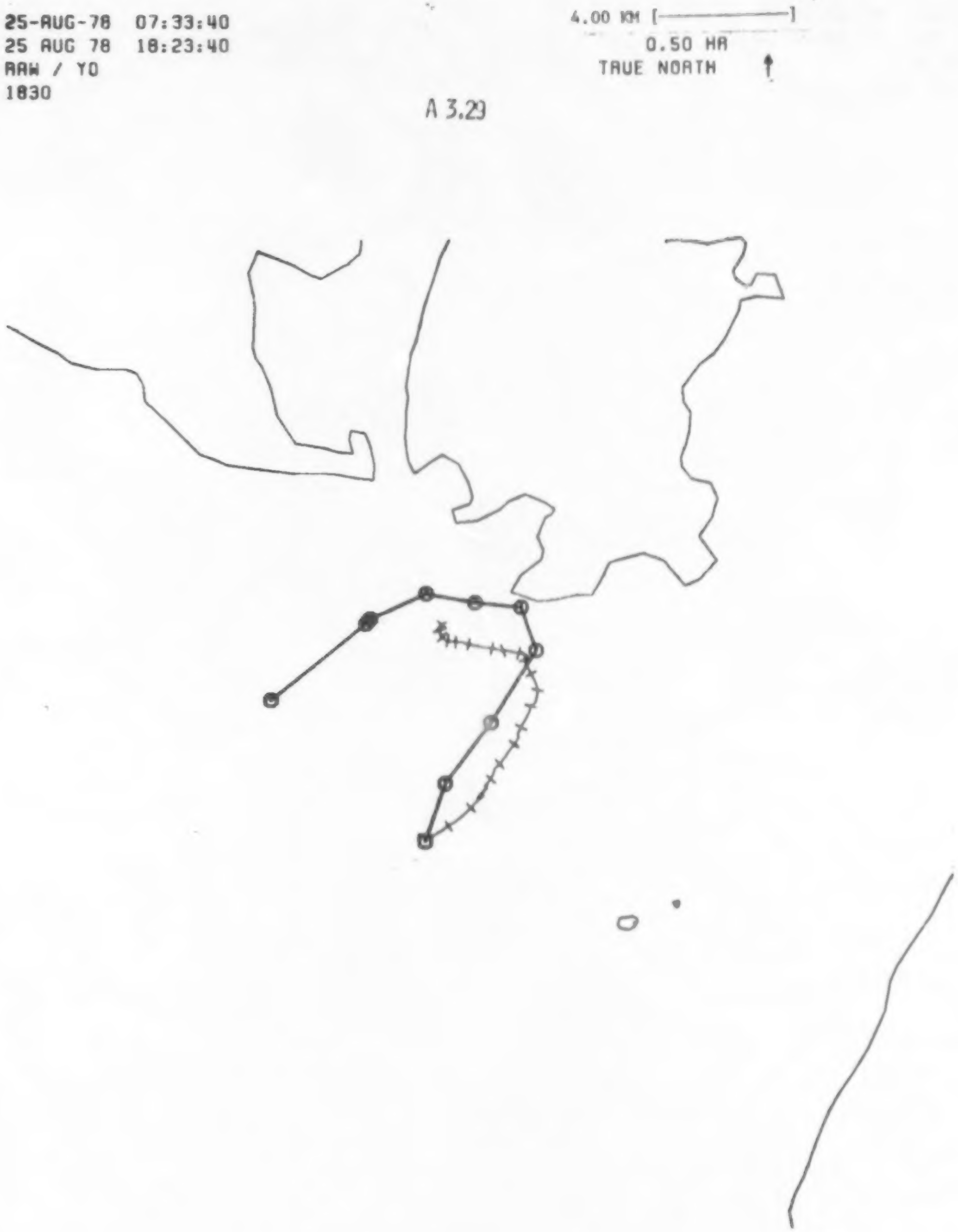
4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

A 3.28



25-AUG-78 07:33:40
25 AUG 78 18:23:40
RAW / YO
1830

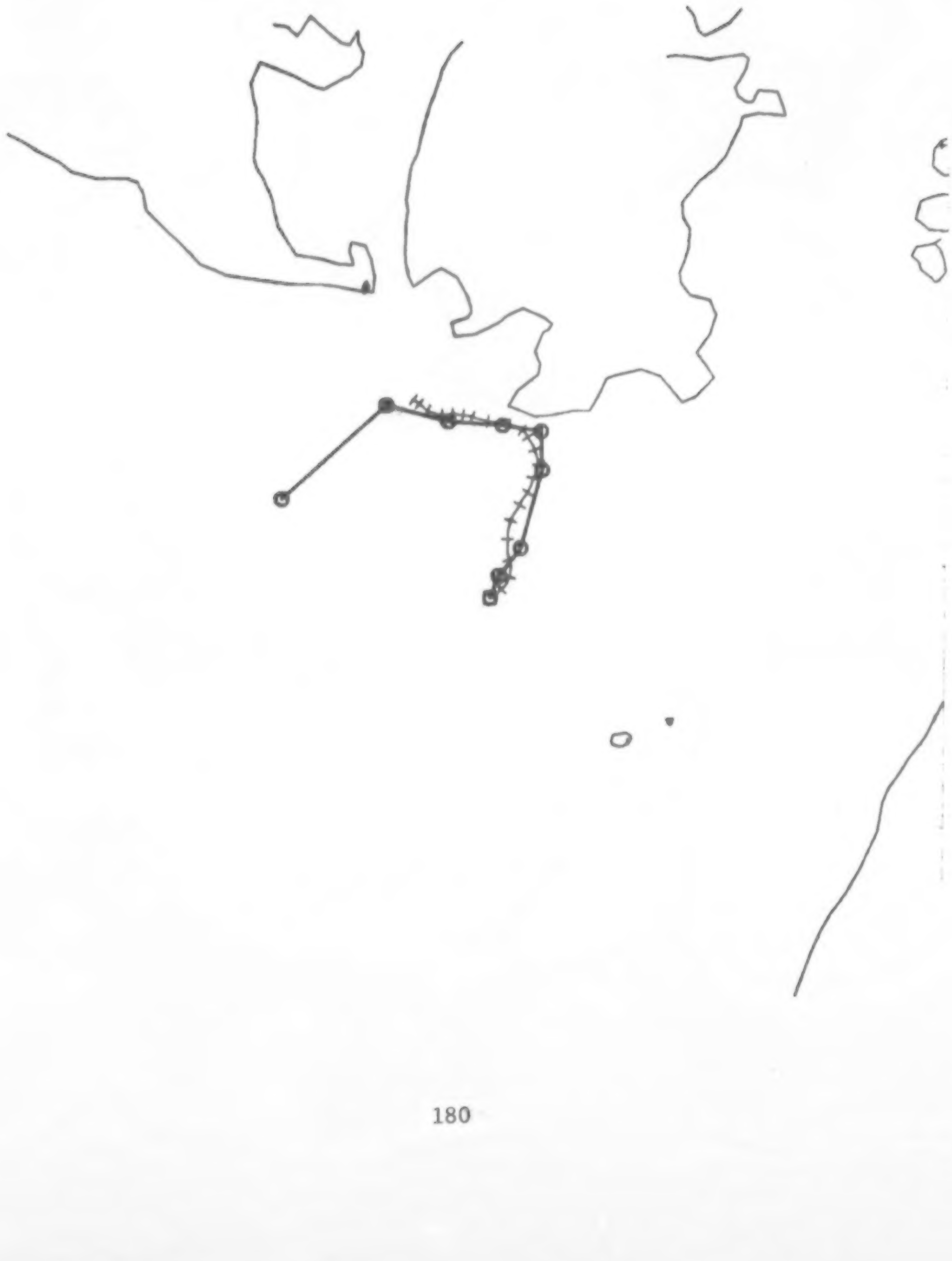
A 3.29


4.00 KM
0.50 HR
TRUE NORTH

25-AUG-78 07:41:00
25 AUG 78 18:21:00
RAW / T1
1829

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

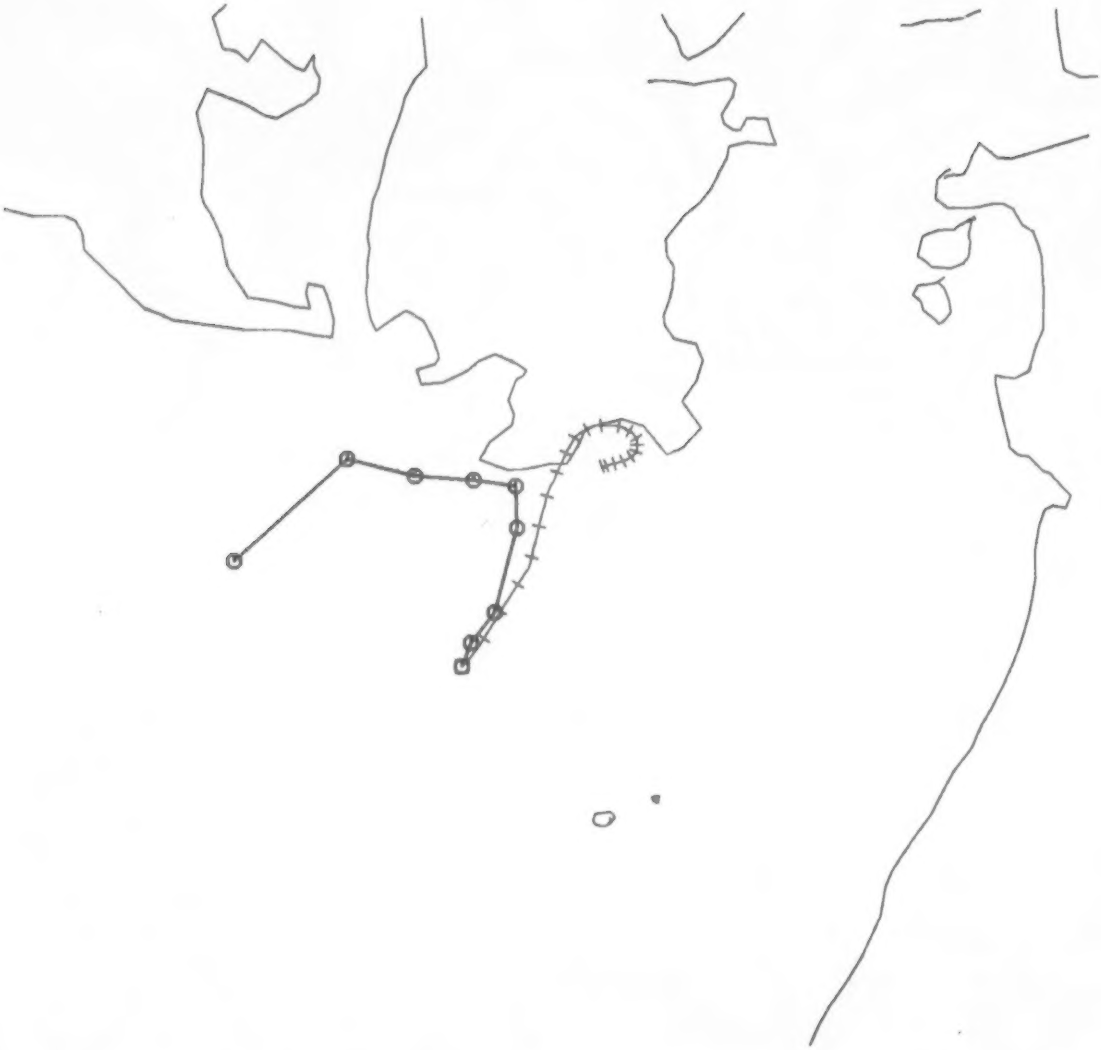
A 3.30



25-AUG-78 07:41:00
25 AUG 78 18:21:00
TID / Y1
1829

4.00 KM [――――――――]
0.50 HR
TRUE NORTH ↑

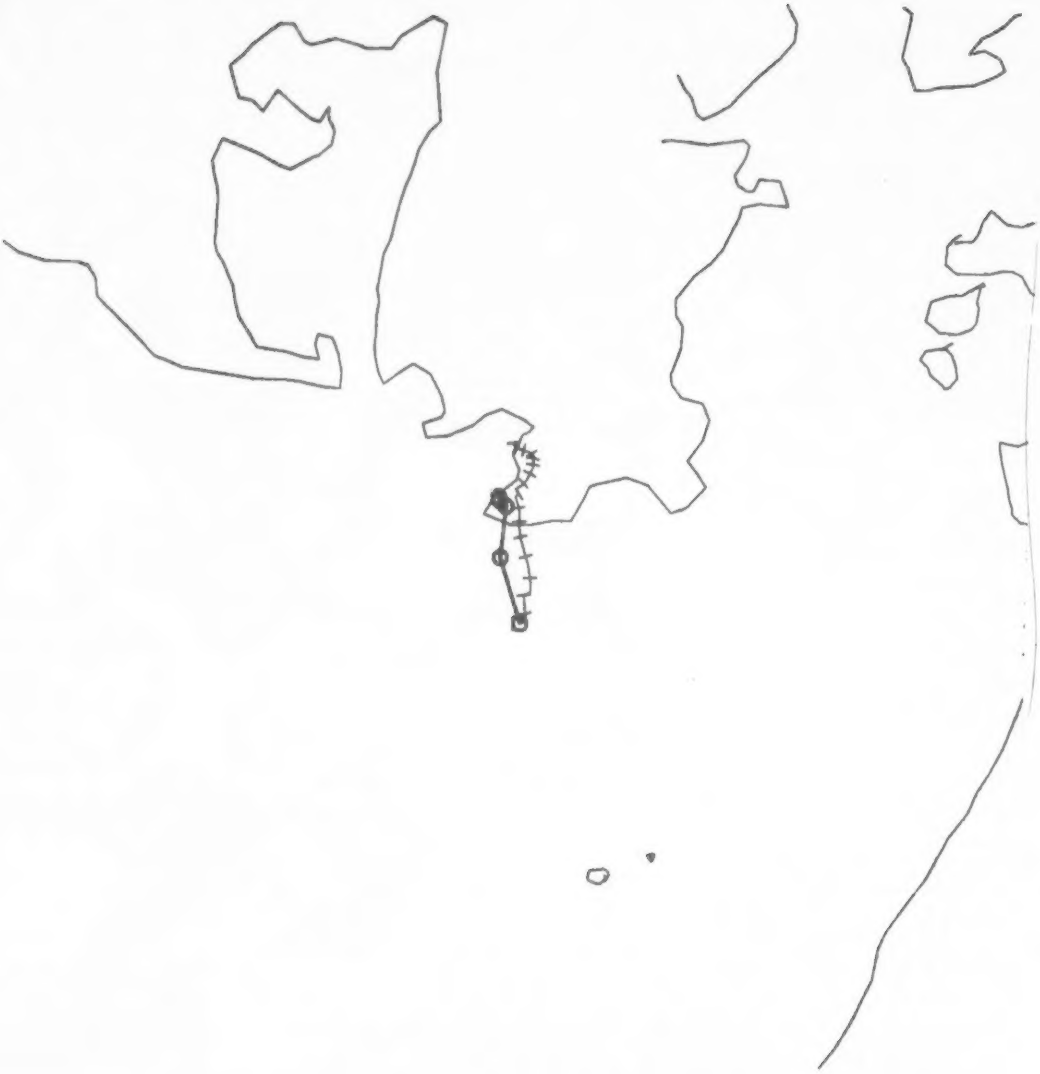
A 3.31



25-AUG-78 08:25:00
25 AUG 78 16:25:00
RAW / Y2
1626

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

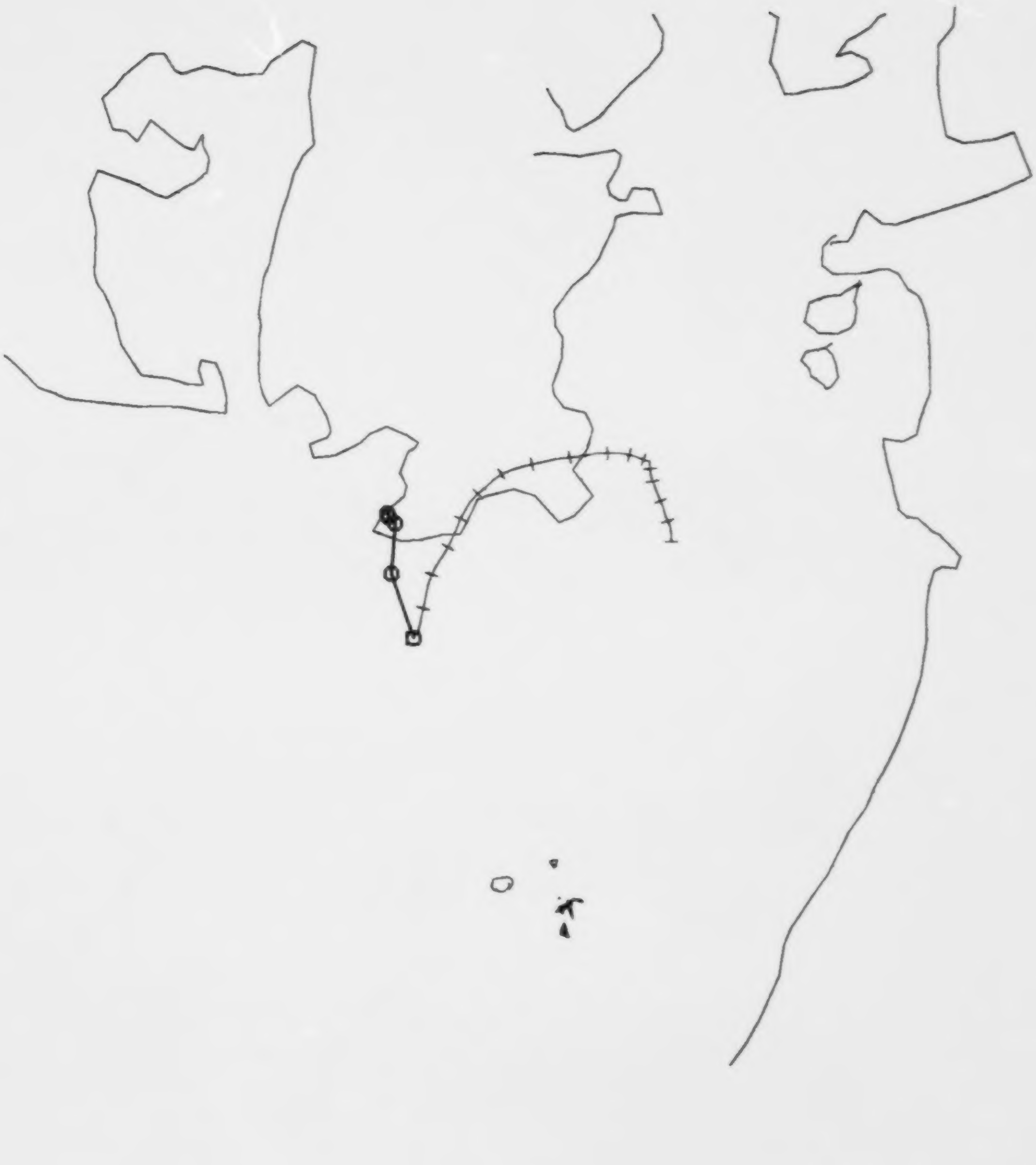
A 3,32



25-AUG-78 08:25:00
25 AUG 78 16:25:00
TIO / Y2
1626

4.00 KM [—————]
0.50 HR
TRUE NORTH ↑

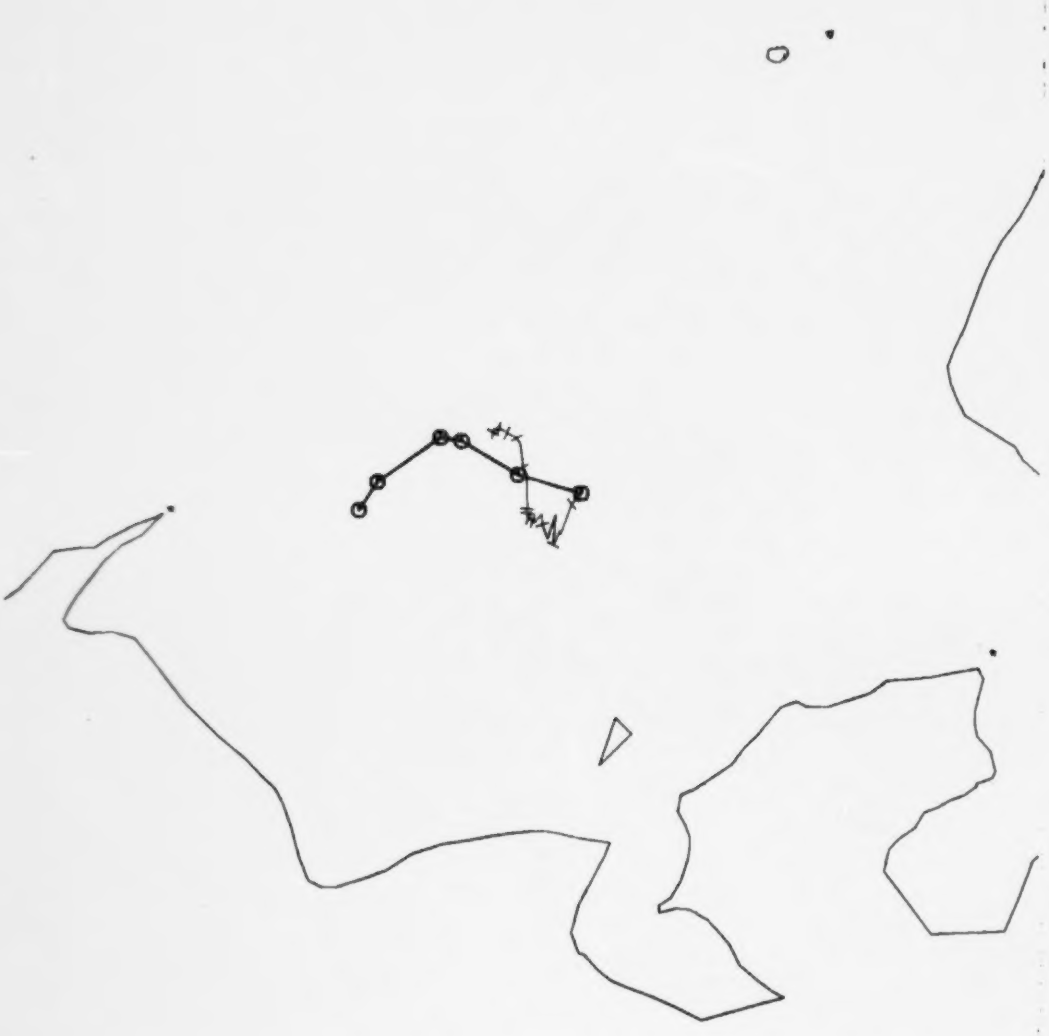
A 3.33



25-AUG-78 12:05:55
25 AUG 78 18:25:55
RAW / YM
1833

4.00 KM [—————]
0.50 HR
TRUE NORTH ↑

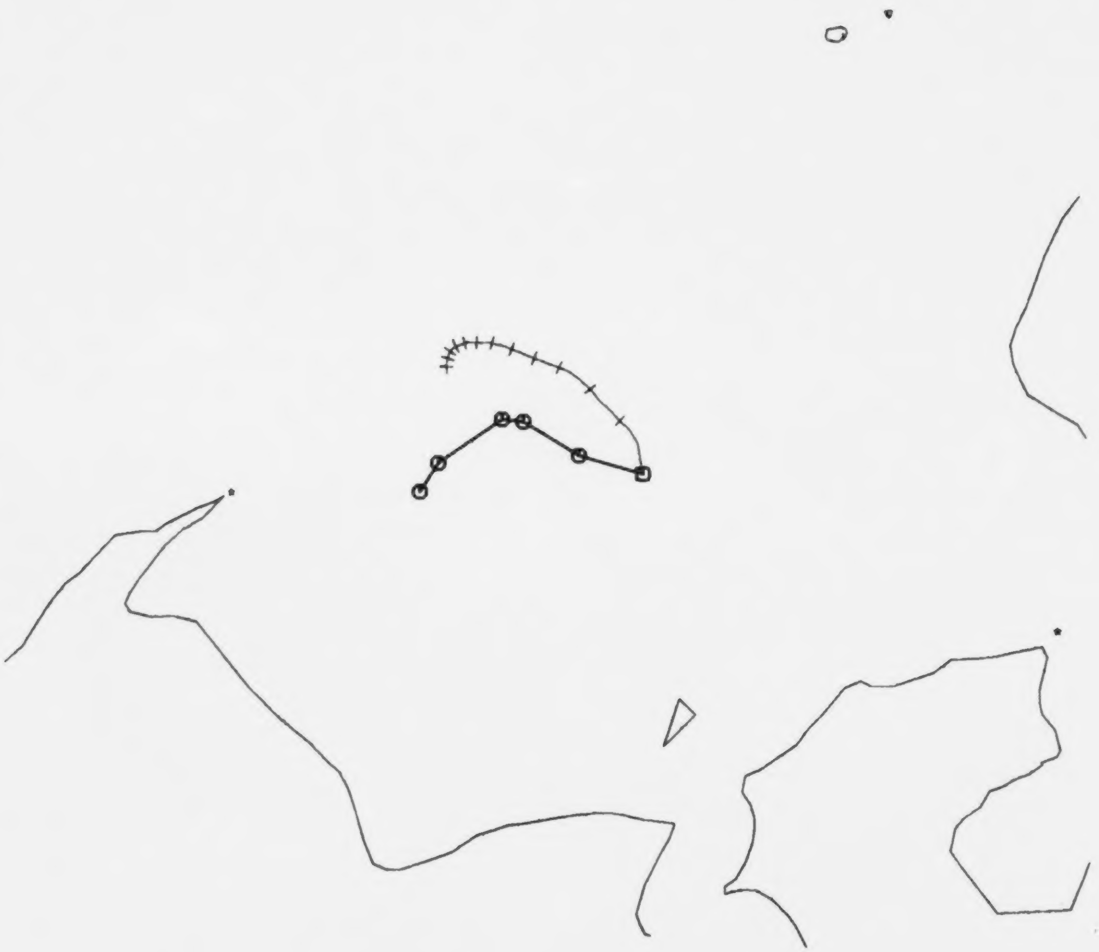
A 3.34



25-AUG-78 12:05:55
25 AUG 78 18:25:55
TID / Y4
1833

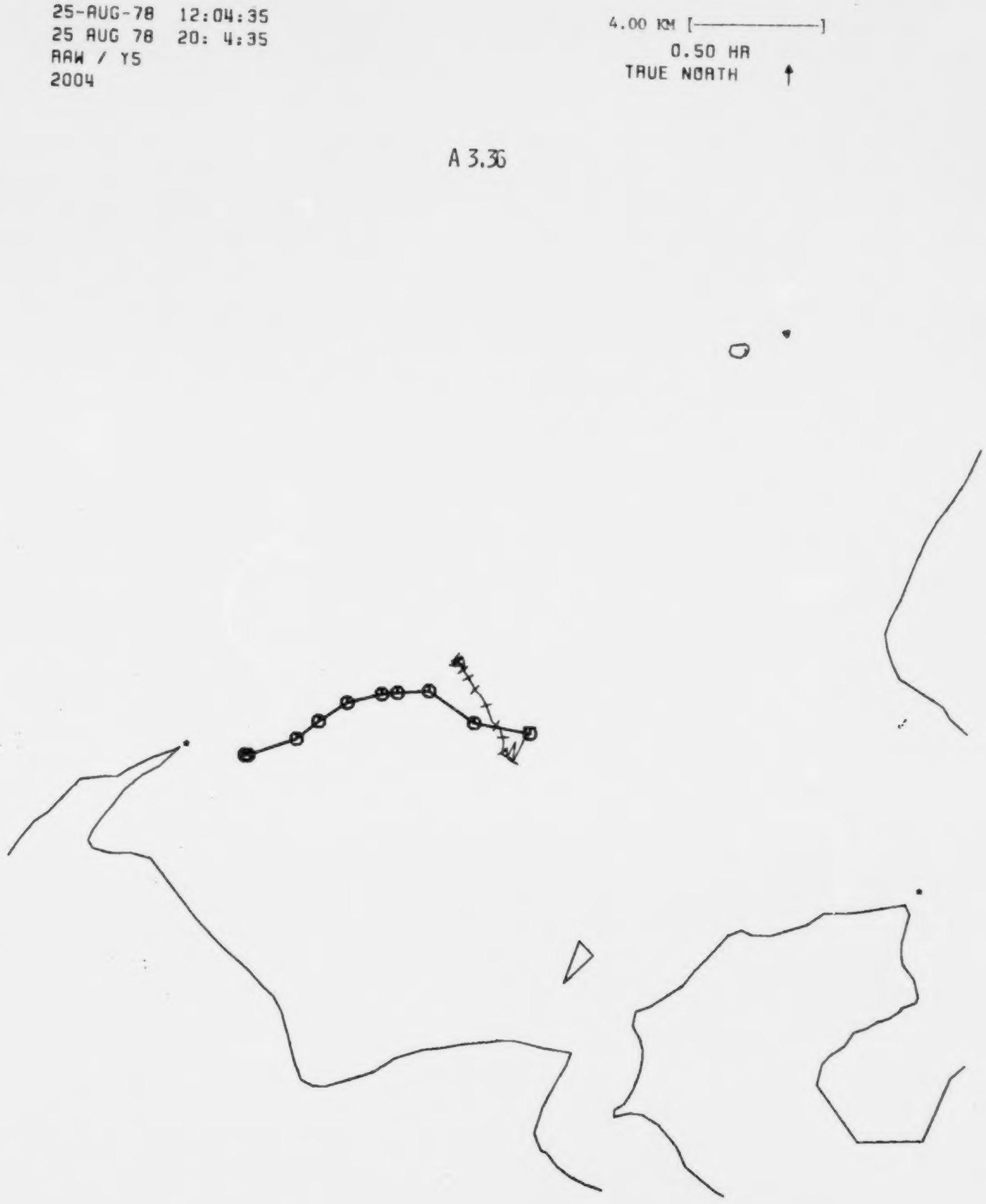
4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

A 3.35



25-AUG-78 12:04:35
25 AUG 78 20: 4:35
AAW / Y5
2004

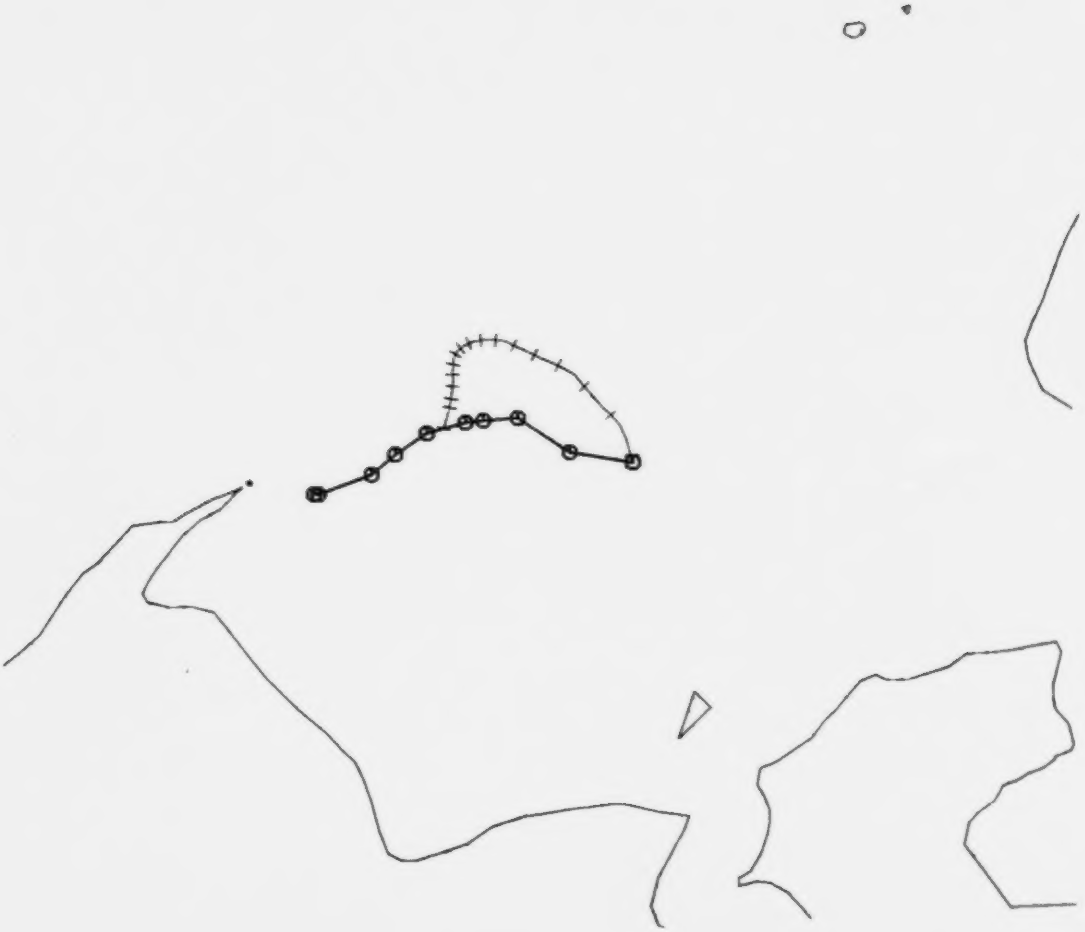
A 3.36


4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

25-AUG-78 12:04:35
25 AUG 78 20: 4:35
TID / Y5
2004

4.00 KM [--------------]
0.50 HR
TRUE NORTH ↑

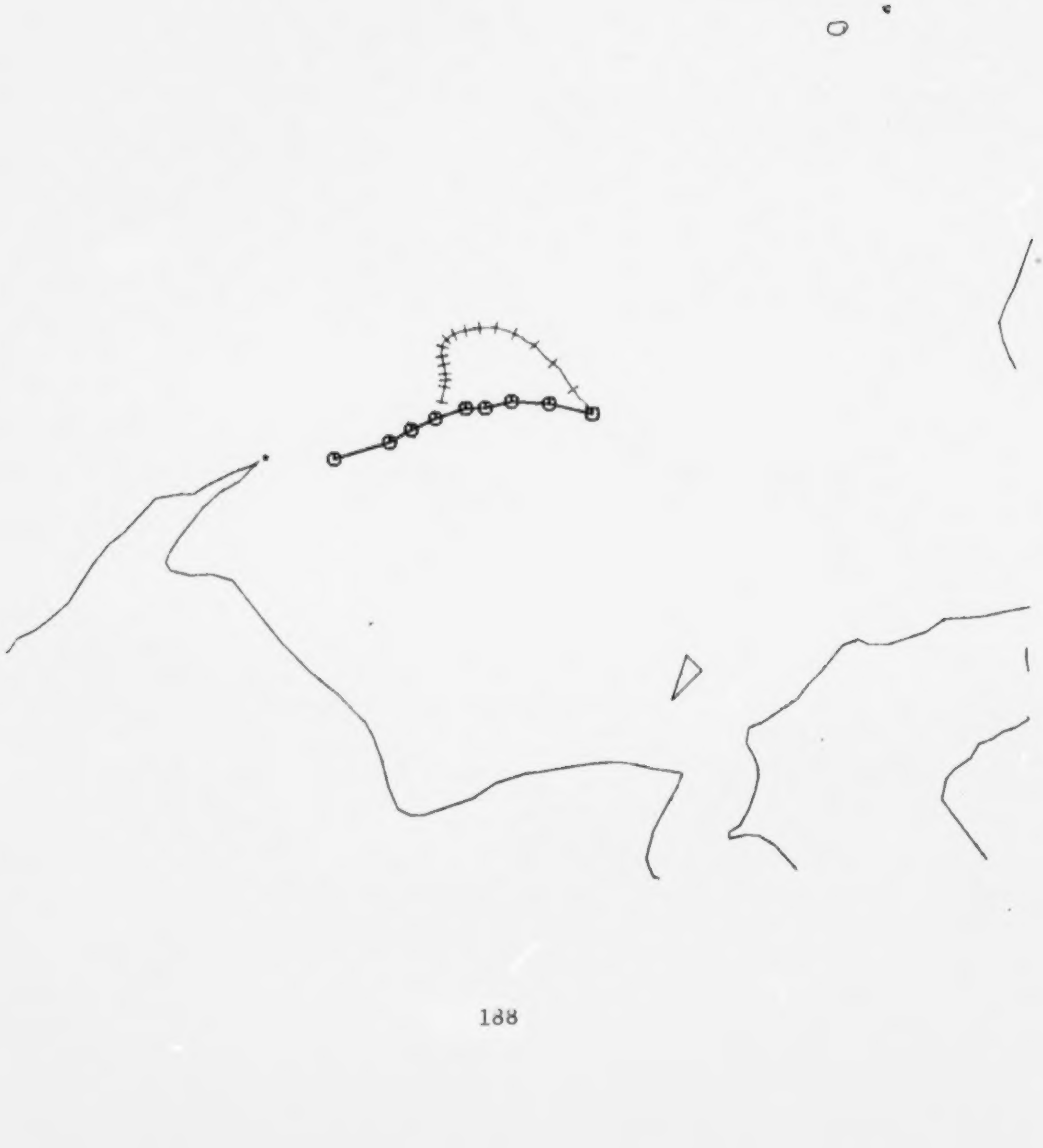
A 3.37



25-AUG-78 12:02:45
25 AUG 78 20: 2:45
TID / Y6
2003

4.00 KM [————————]
0.50 HR
TRUE NORTH ↑

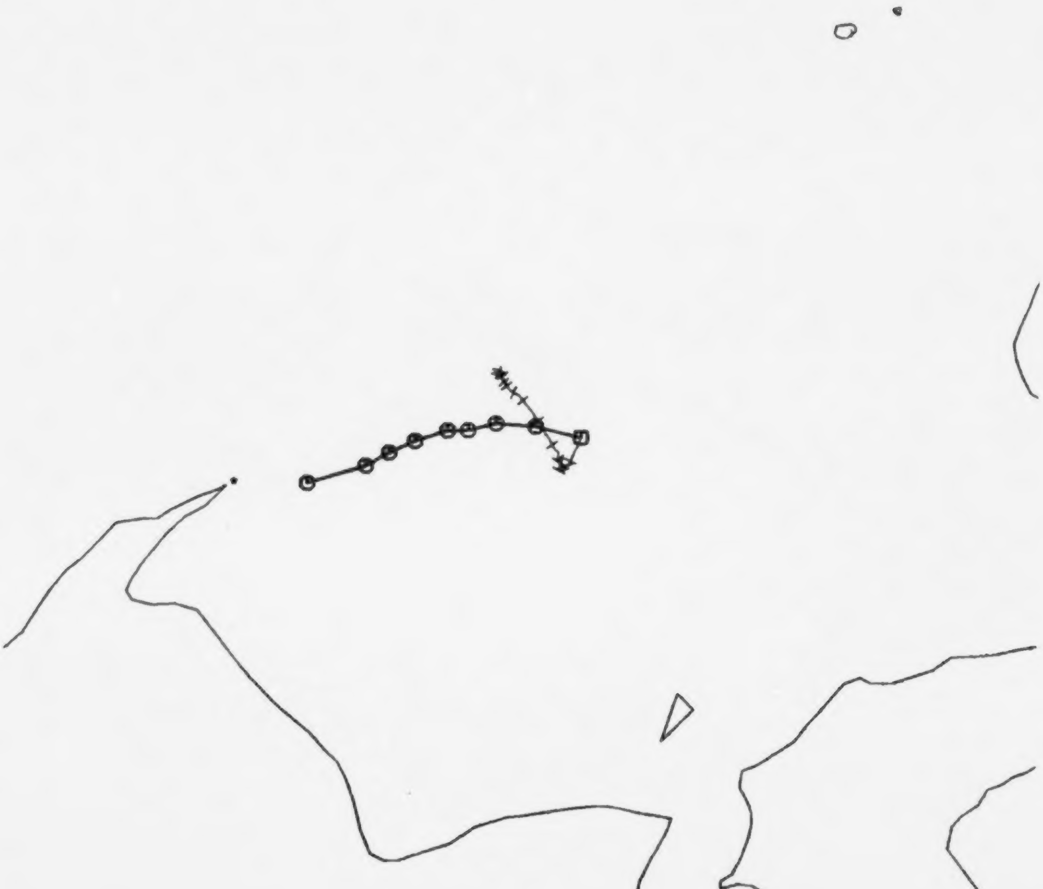
A 3.38



25-AUG-78 12:02:45
25 AUG 78 20: 2:45
RAW / Y6
2003

4.00 KM [------------------]
0.50 HR
TRUE NORTH ↑

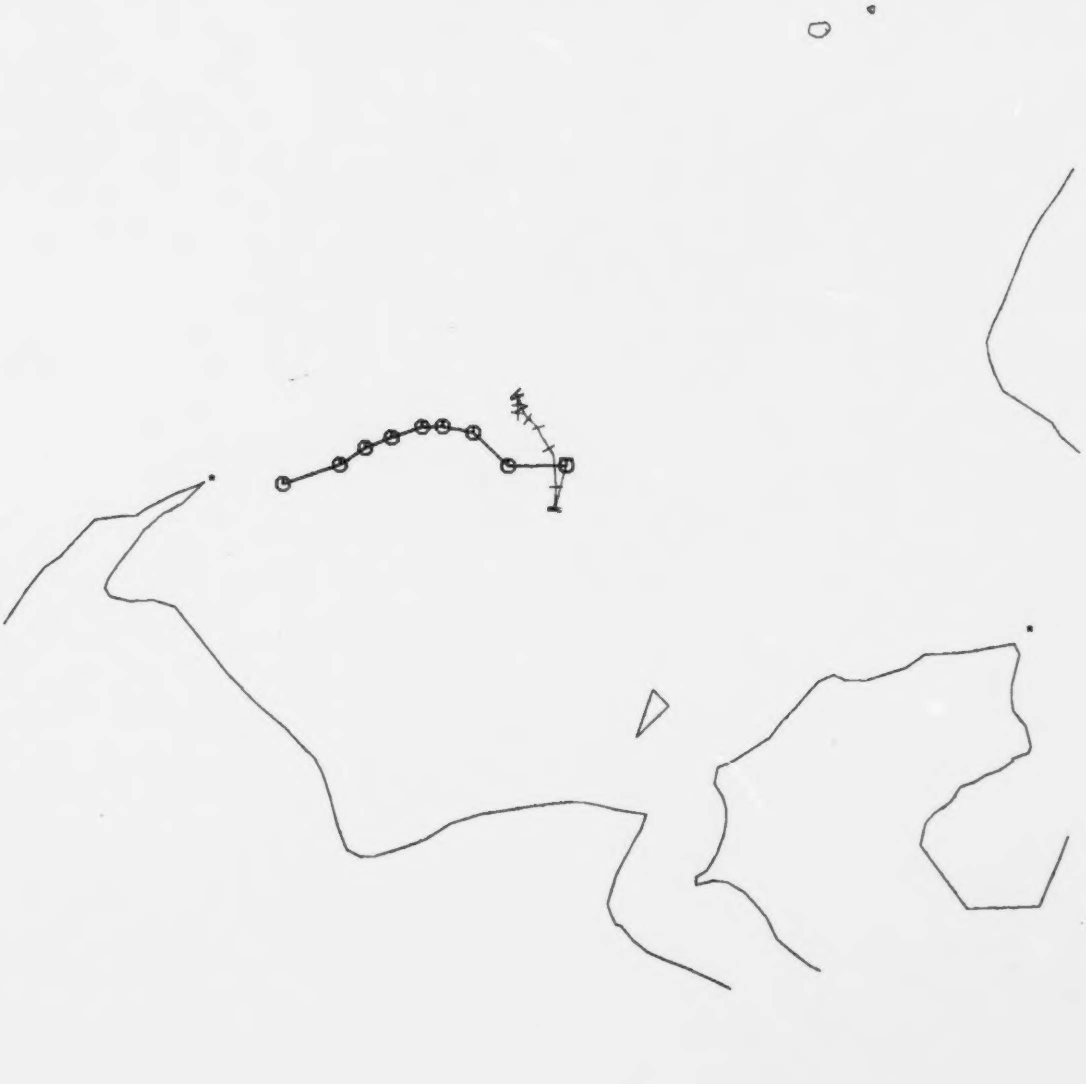
A 3.39



25-AUG-78 12:03:35
25 AUG 78 19:53:35
RAW / Y7
2001

4.00 KM [――――――]
0.50 HR
TRUE NORTH ↑

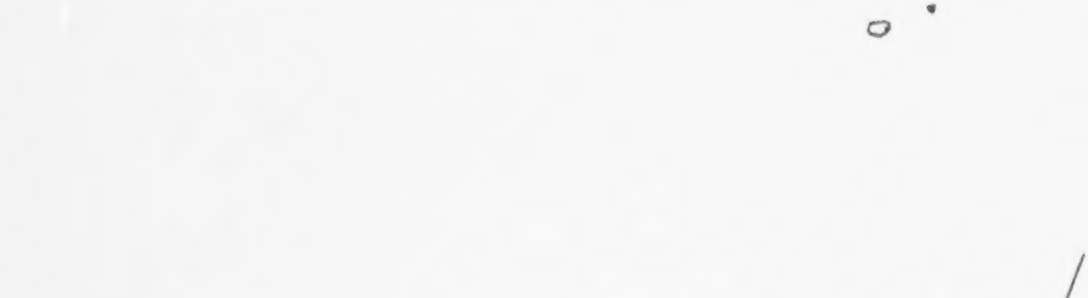
A 3.40



25-AUG-78 12:03:35
25 AUG 78 19:53:35
TID / Y7
2001

4.00 KM [-------------]
0.50 HR
TRUE NORTH ↑

A 3.41



25-AUG-78 13:24:00
25 AUG 78 19:44:00
RAW / Y8
1953

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

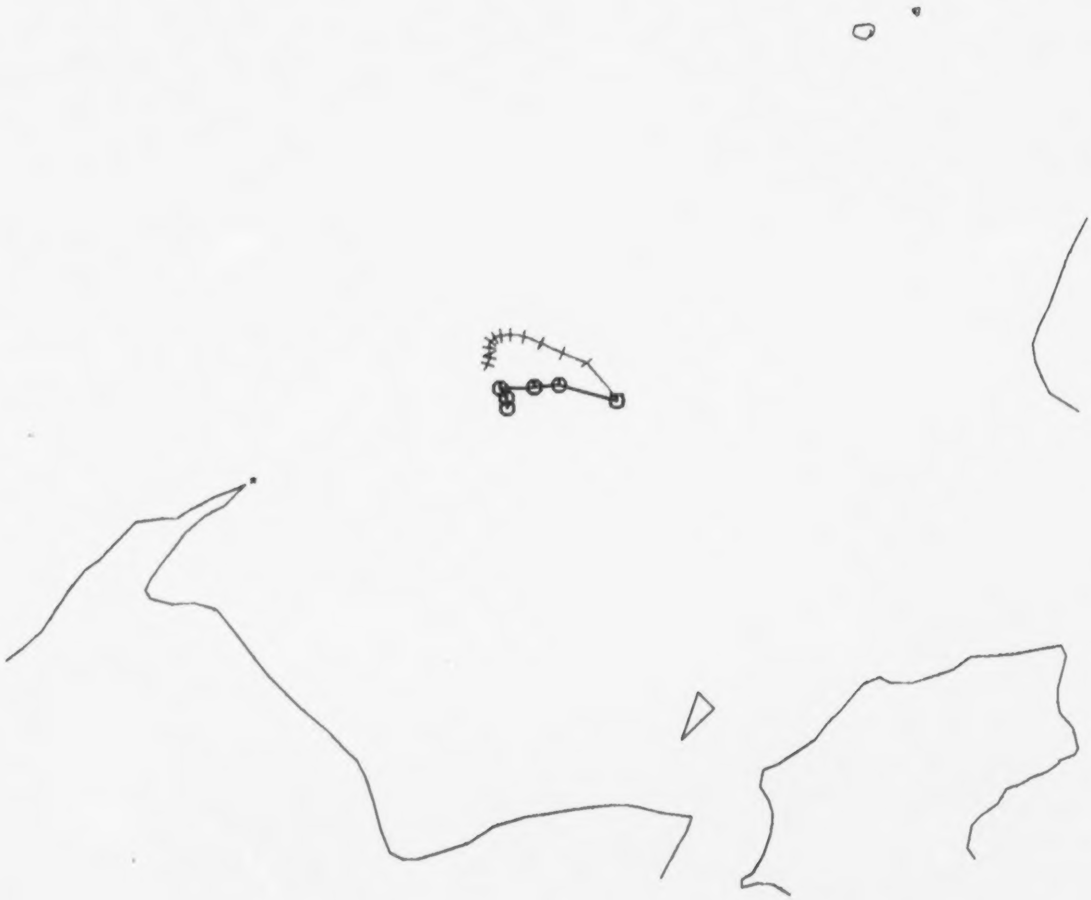
A3.42

25-AUG-78 13:24:00
25 AUG 78 19:44:00
TID / Y8
1953

4.00 KM [-------------]

0.50 HR
TRUE NORTH ↑

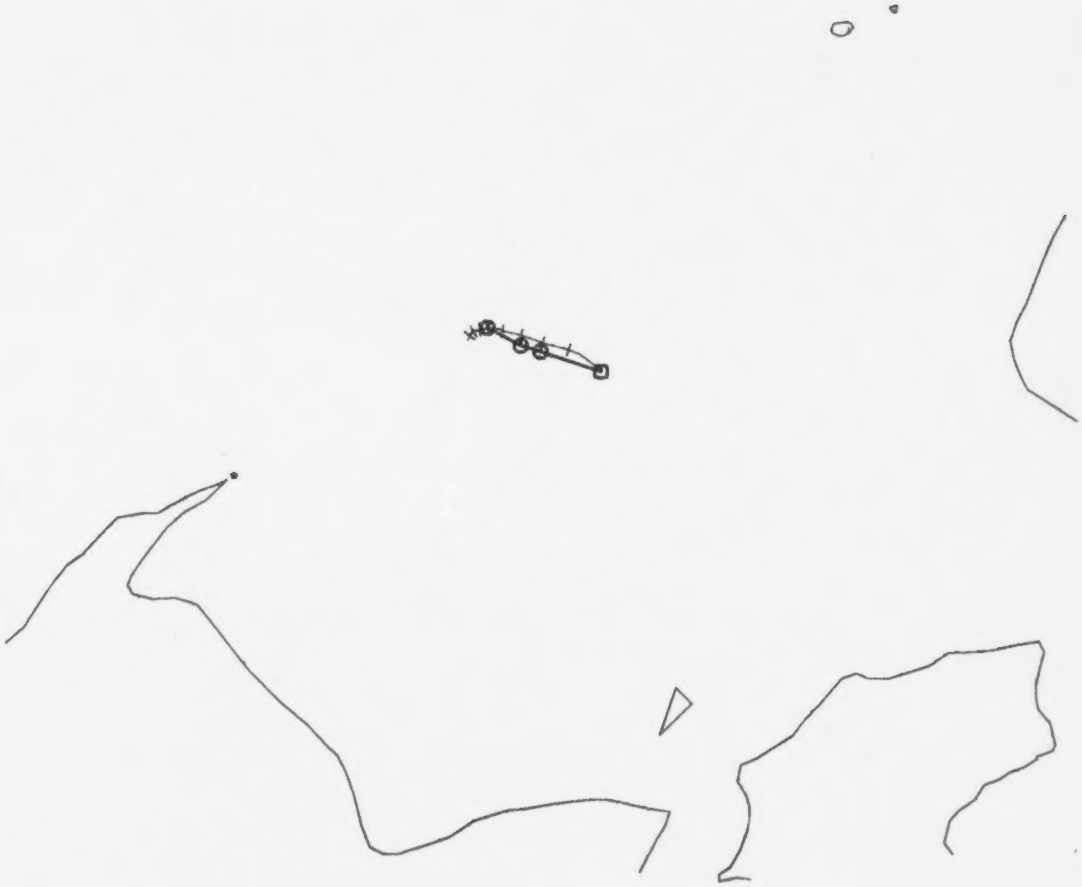
A 3.43



25-AUG-78 13:23:05
25 AUG 78 17:43:05
TID / Y9
1743

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

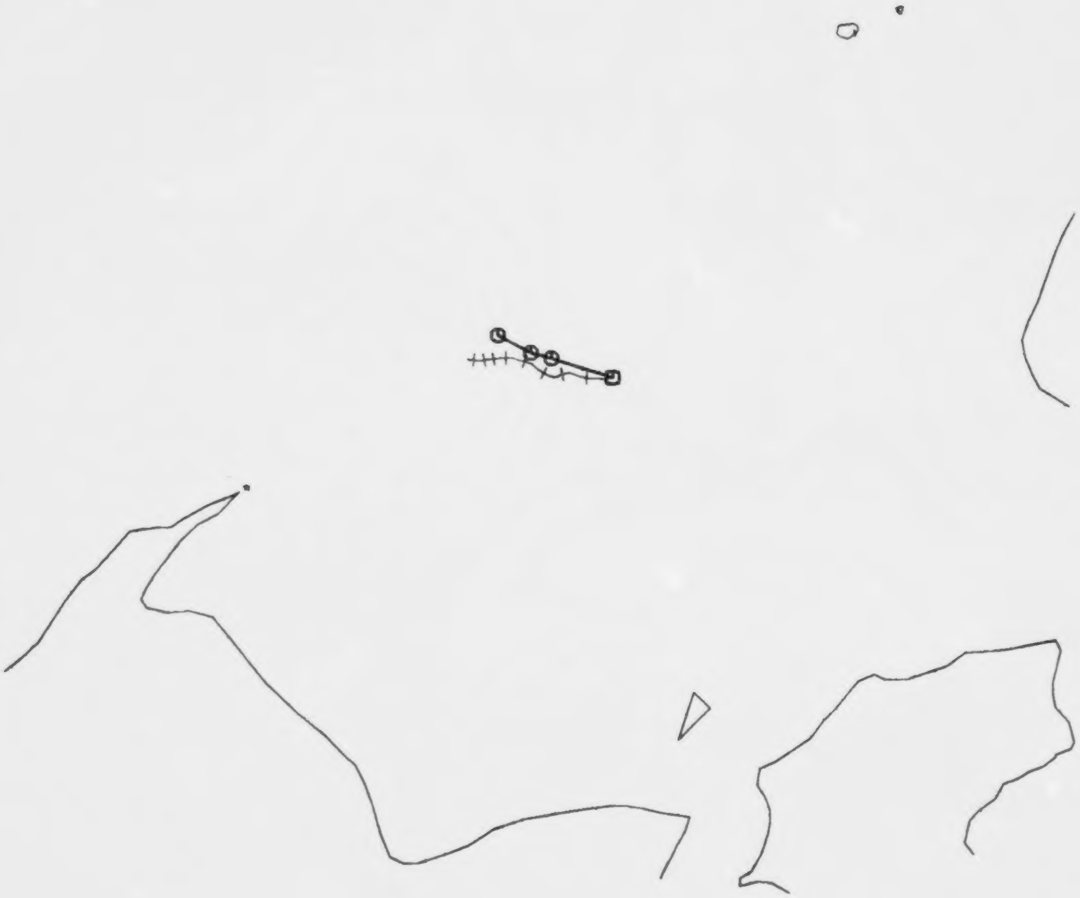
A 3.44



25-AUG-78 13:23:05
25 AUG 78 17:43:05
RAW / Y9
1743

A 3.45

4.00 KM [——————]
0.50 HR
TRUE NORTH ↑

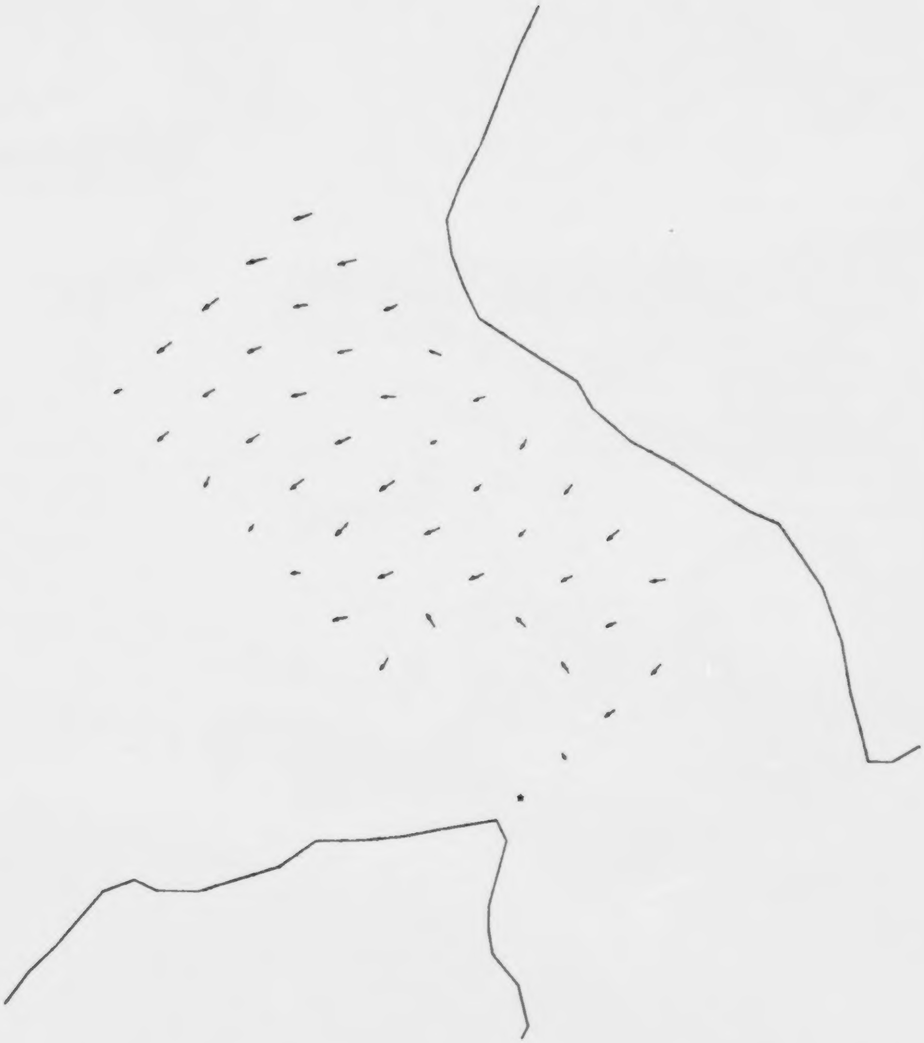


22-AUG-78 21:00:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [-------------]
200 CM/S [-------------]

TRUE NORTH ↑

A 4.00

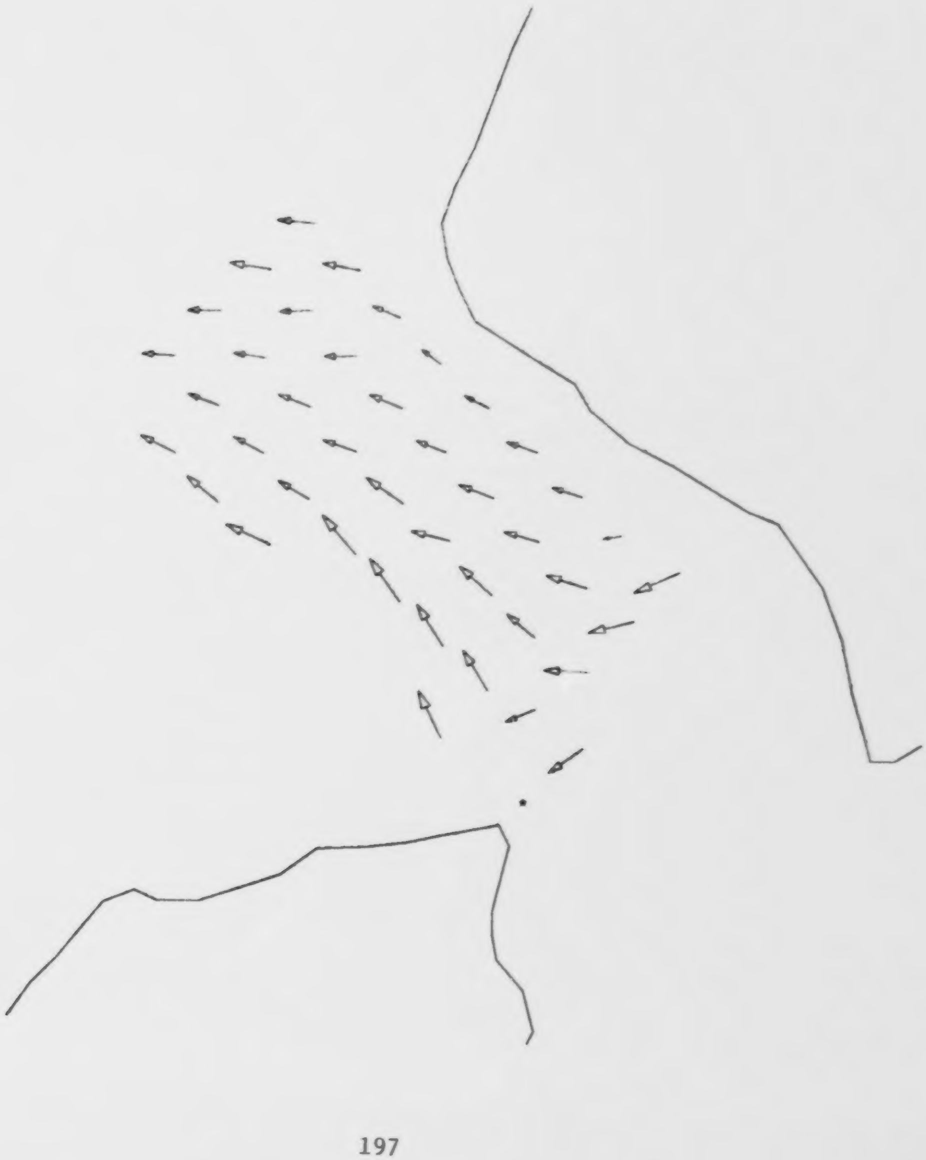


22 AUG 78 22: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.01

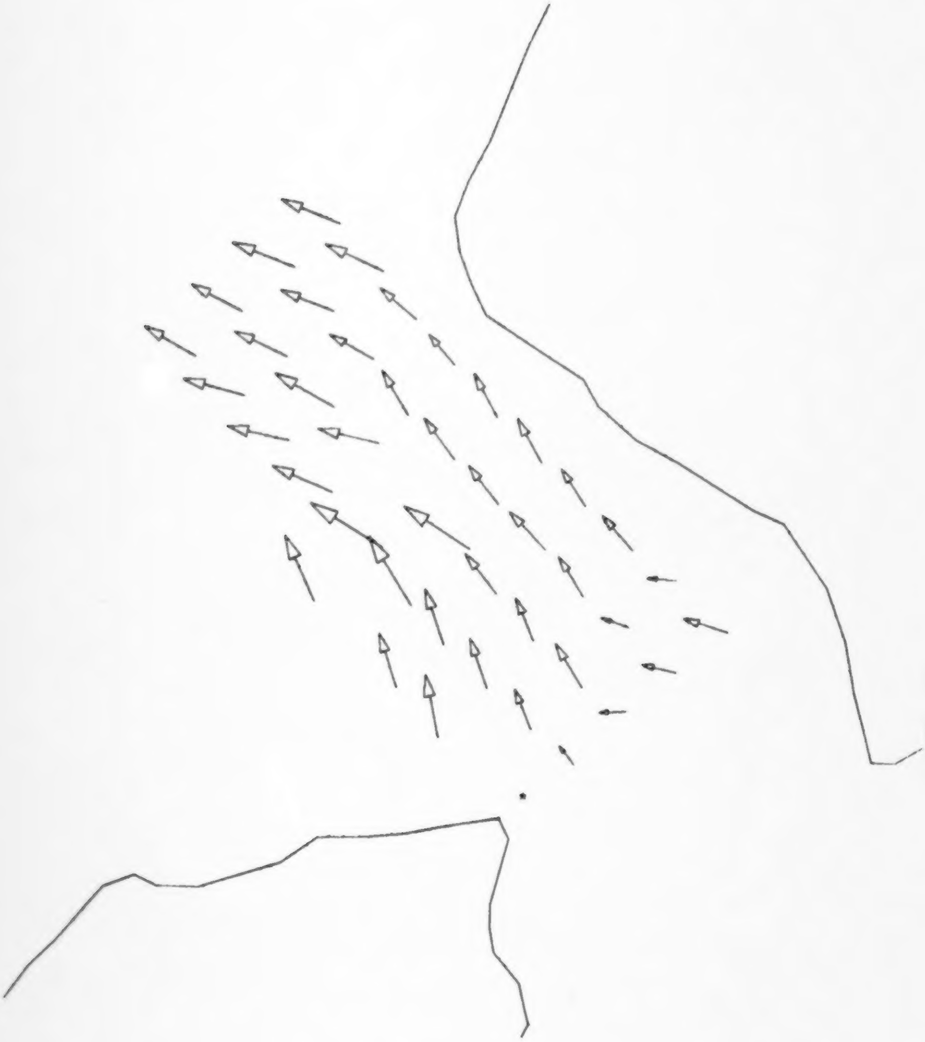


22 AUG 78 23: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

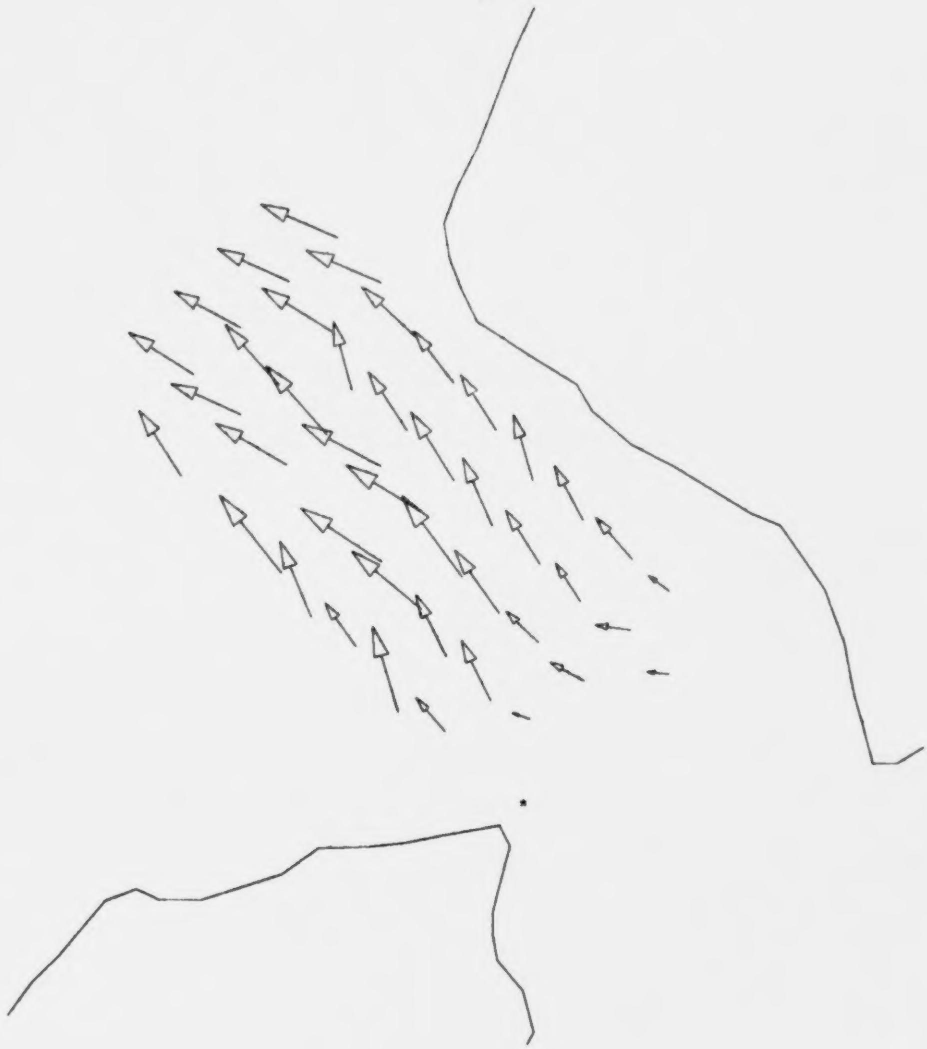
A 4.32



23 AUG 78 0: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [————————]
200 CM/S [————————]
TRUE NORTH ↑

A 4.J3

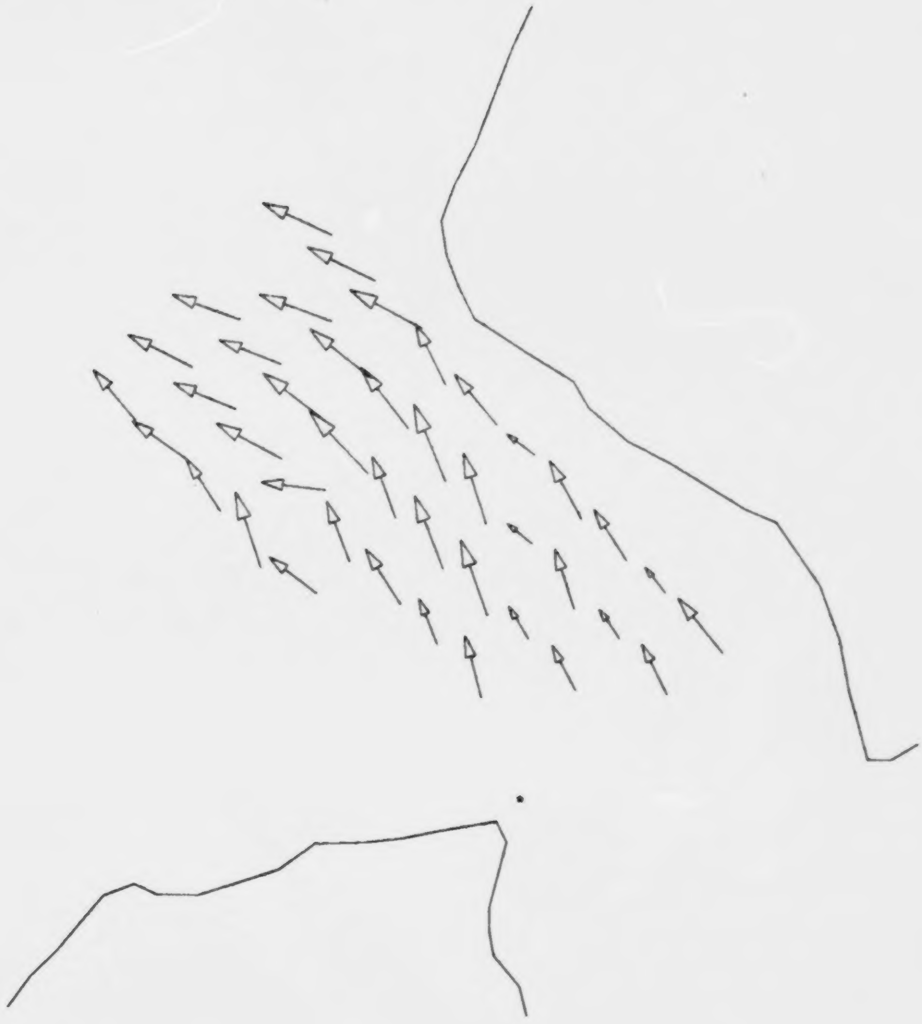


23 AUG 78 1: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [――――――――]
200 CM/S [――――――――]

TRUE NORTH ↑

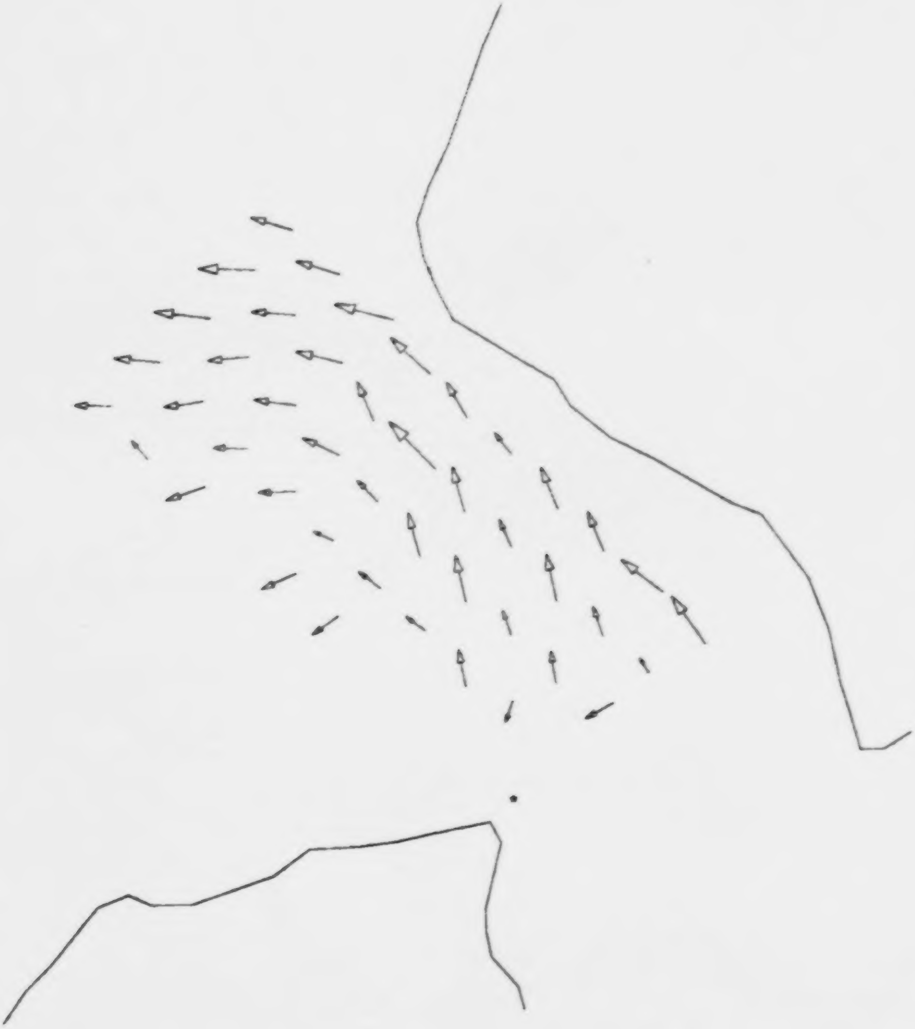
A 4.04



23 AUG 78   2: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

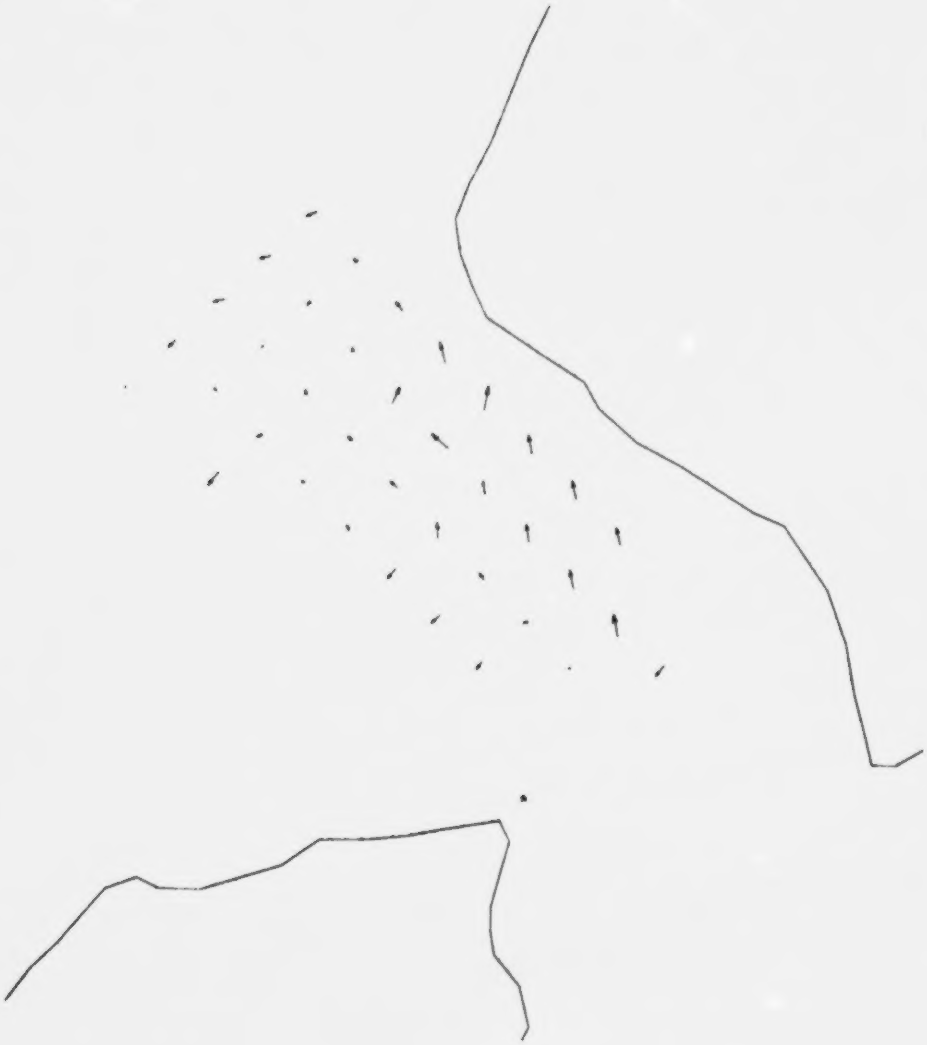
A 4.05



23 AUG 78   3: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [--------------]
200 CM/S [--------------]
TRUE NORTH ↑

A 4.06

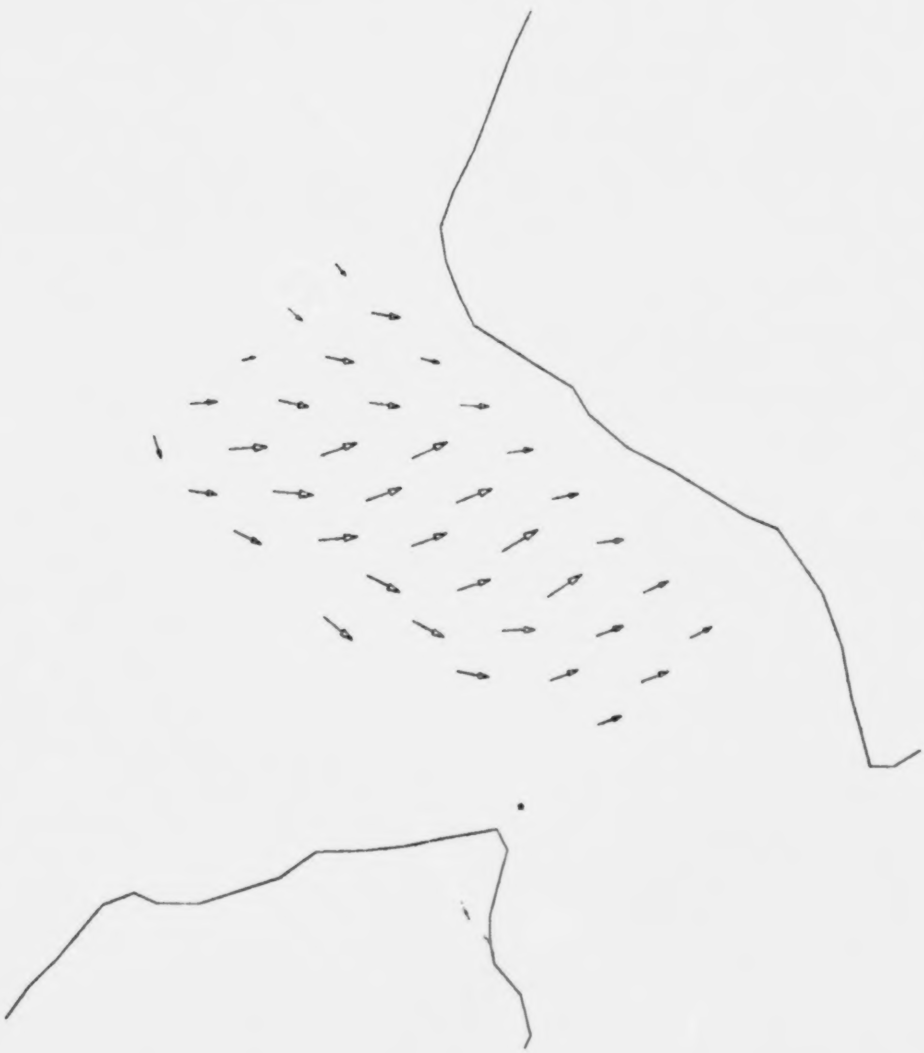


23 AUG 78 4: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [――――――――]
200 CM/S [――――――――]

TRUE NORTH ↑

A 4.07

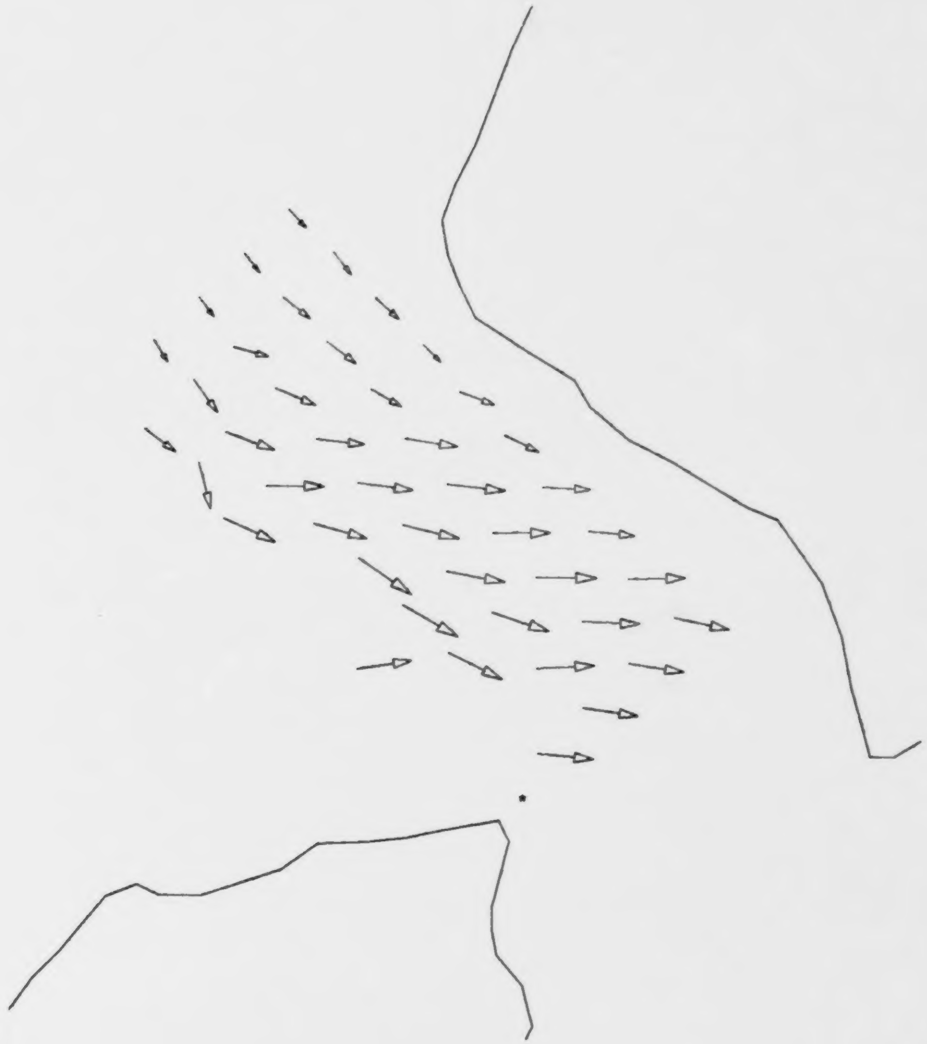


23 AUG 78 5: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [------------]
200 CM/S [------------]

TRUE NORTH ↑

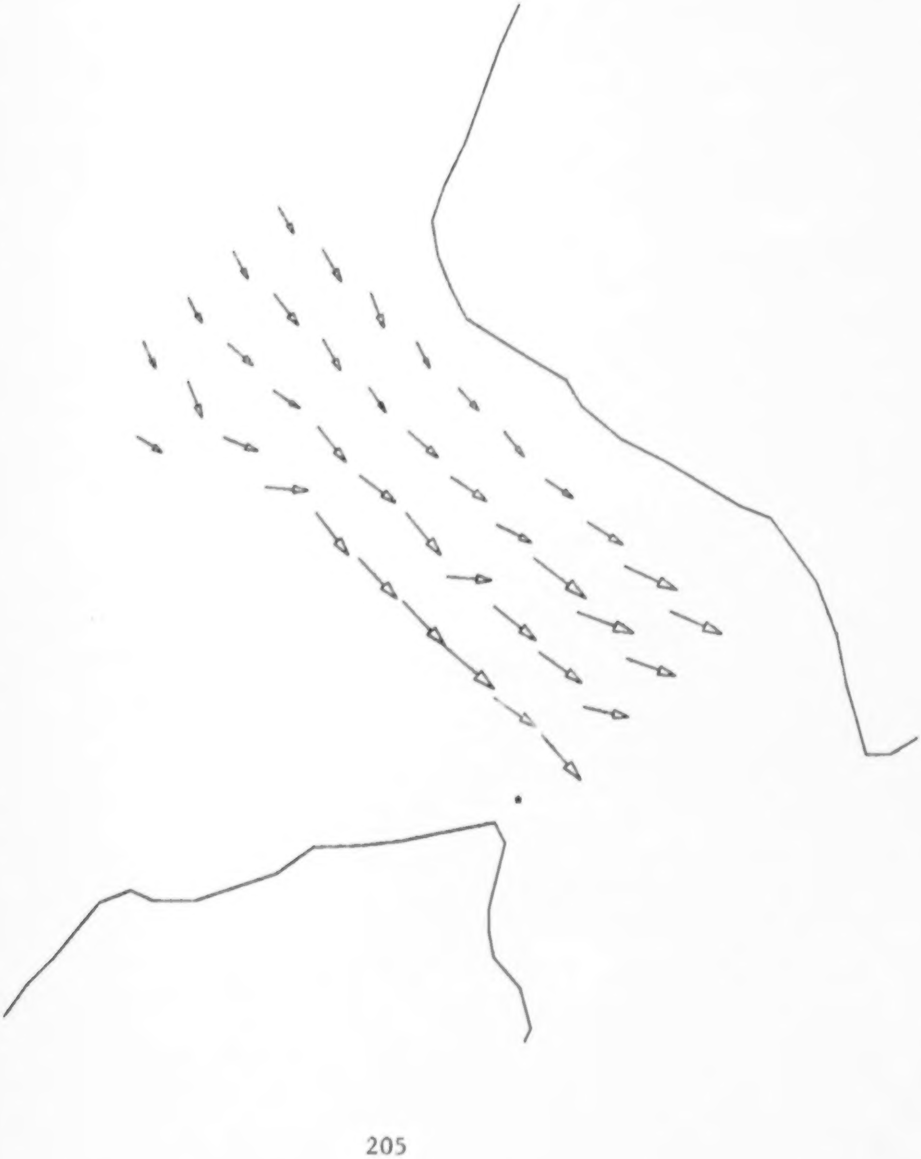
A 4.38



23 AUG 78   6: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

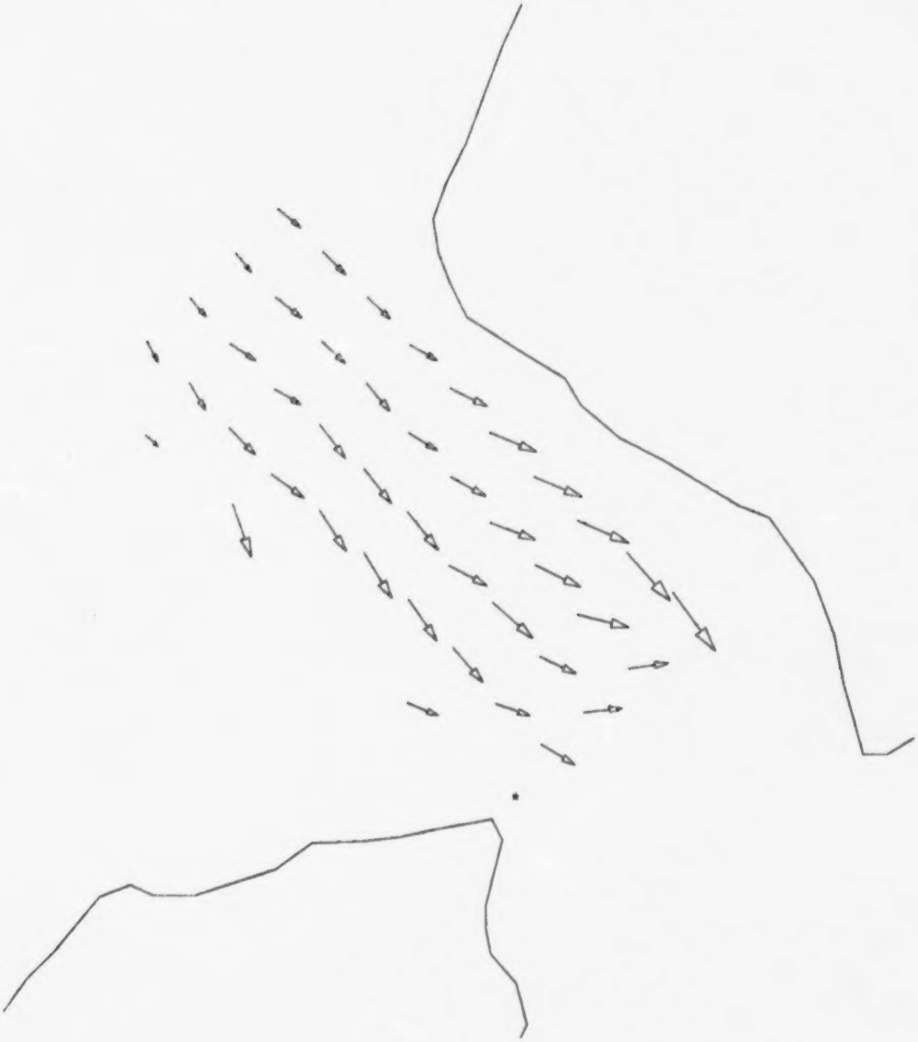
A 4.09



23 AUG 78   7: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.1D

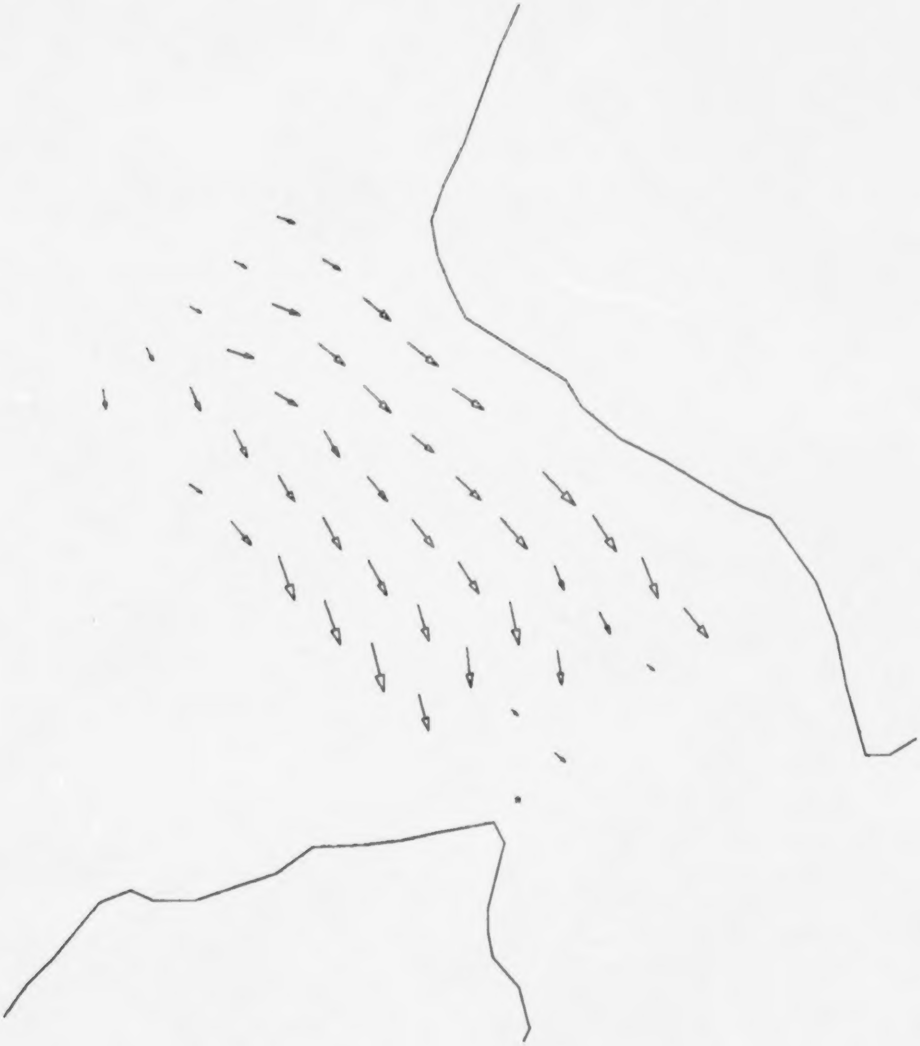


23 AUG 78   8: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.11

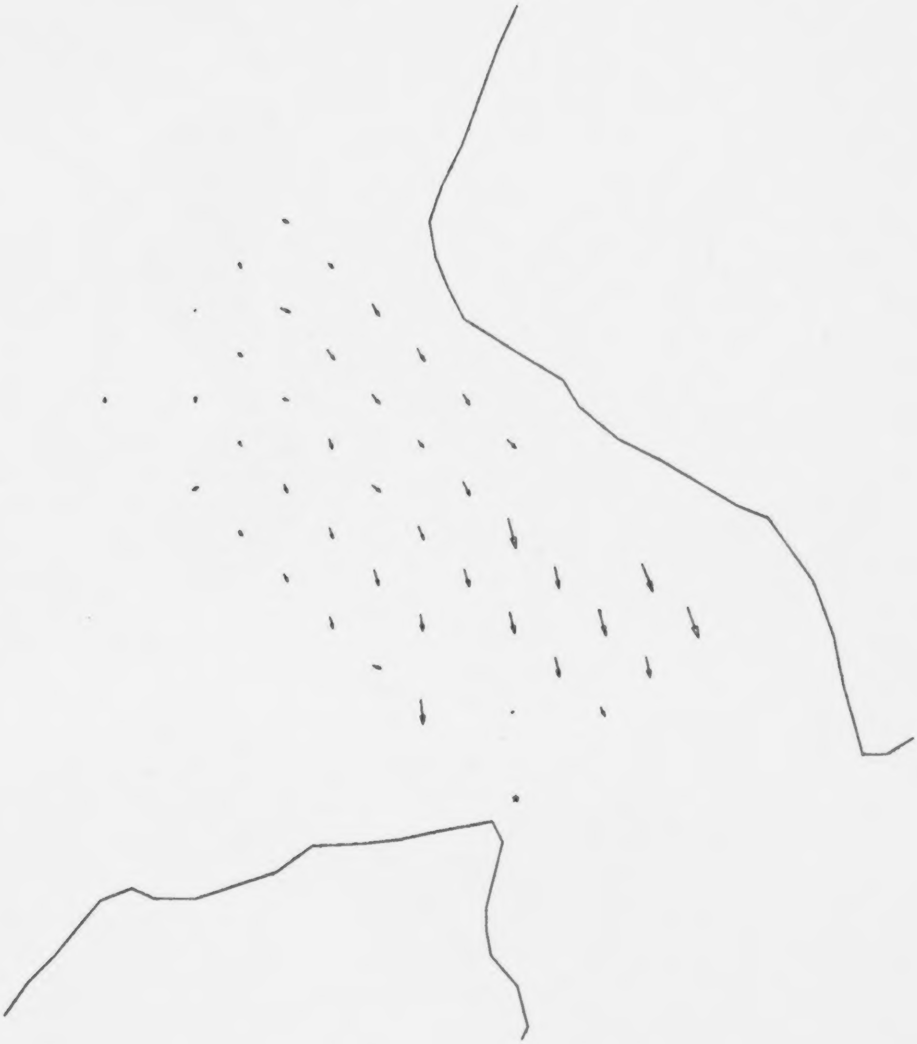


23 AUG 78 9: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.12

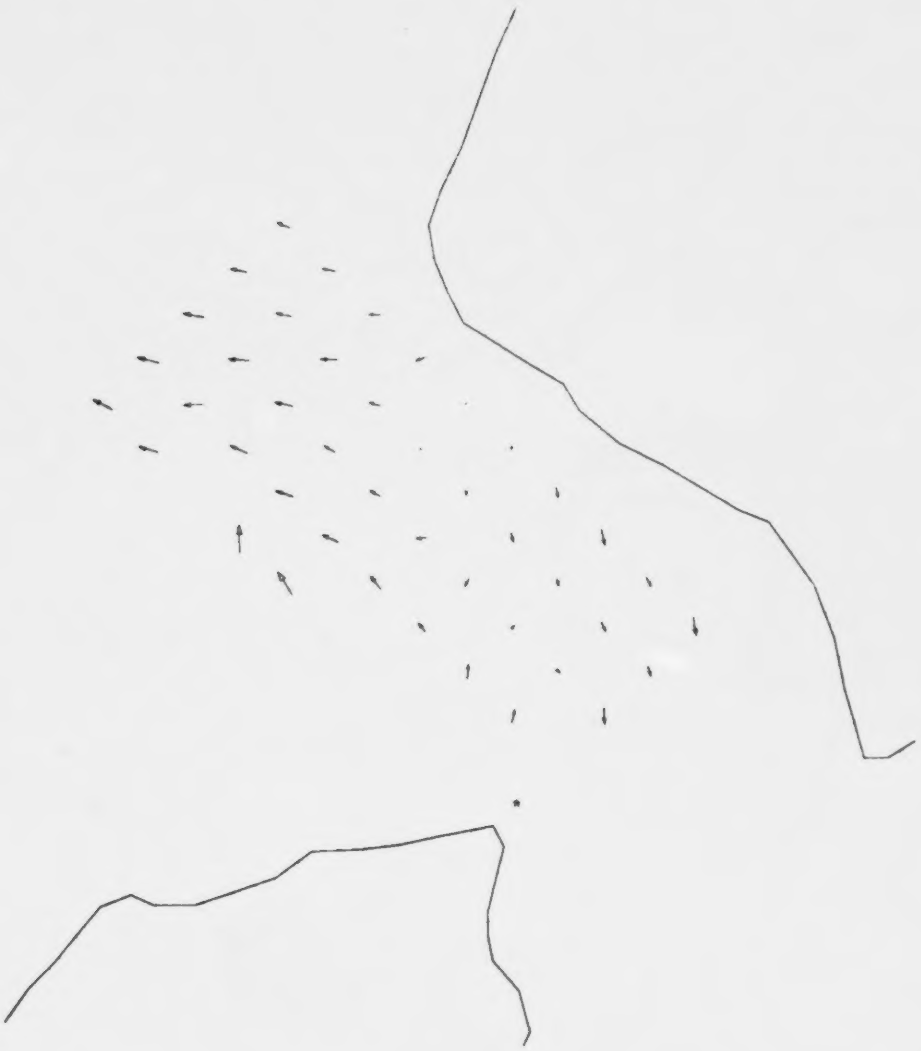


23 AUG 78 10: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.13

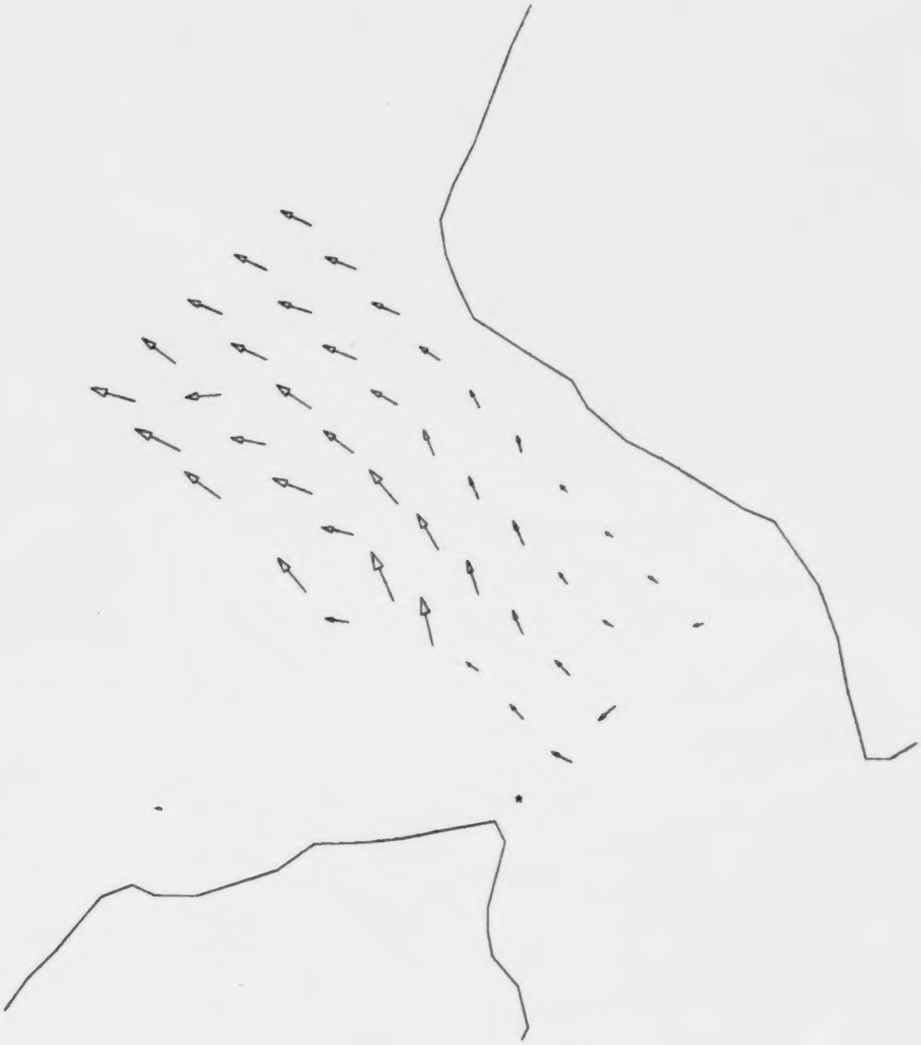


23 AUG 78 11: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

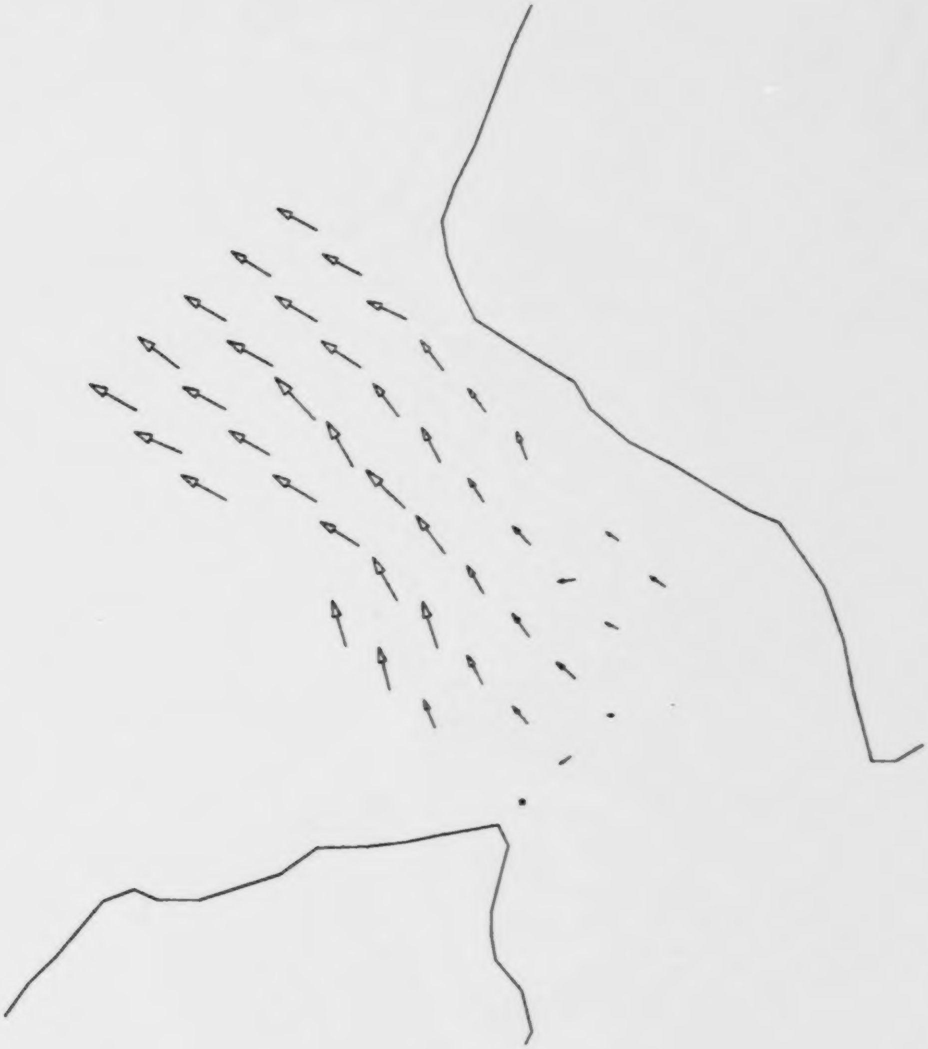
A 4.14



23 AUG 78 12: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [———]
200 CM/S [———]
TRUE NORTH ↑

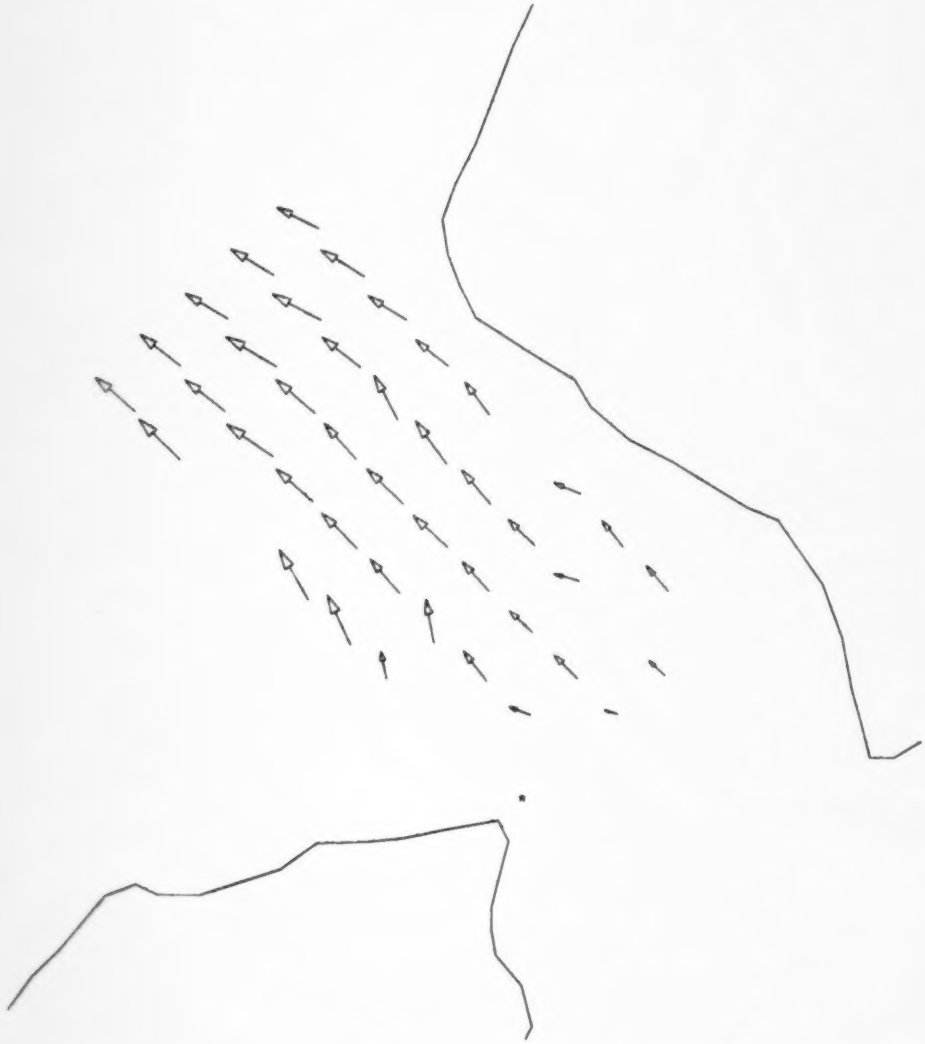
A 4.15



23 AUG 78 13: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.16

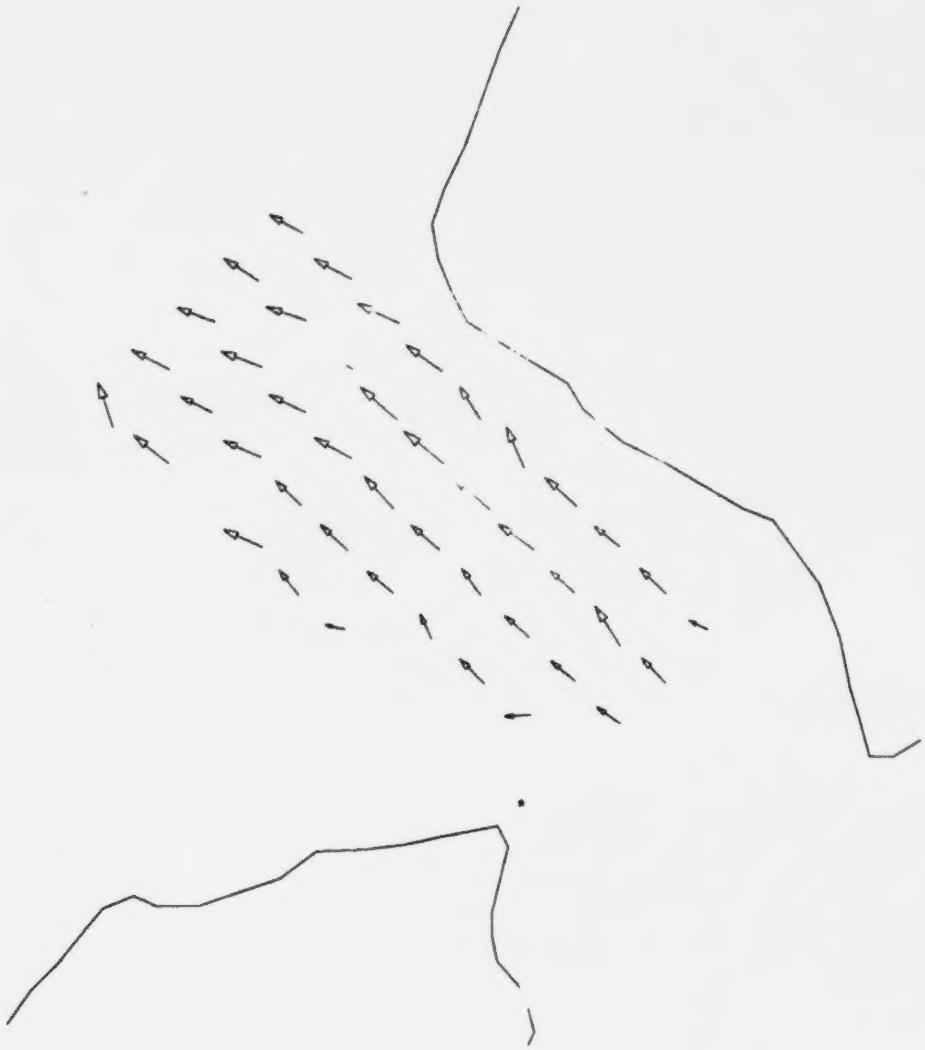


23 AUG 78 14: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

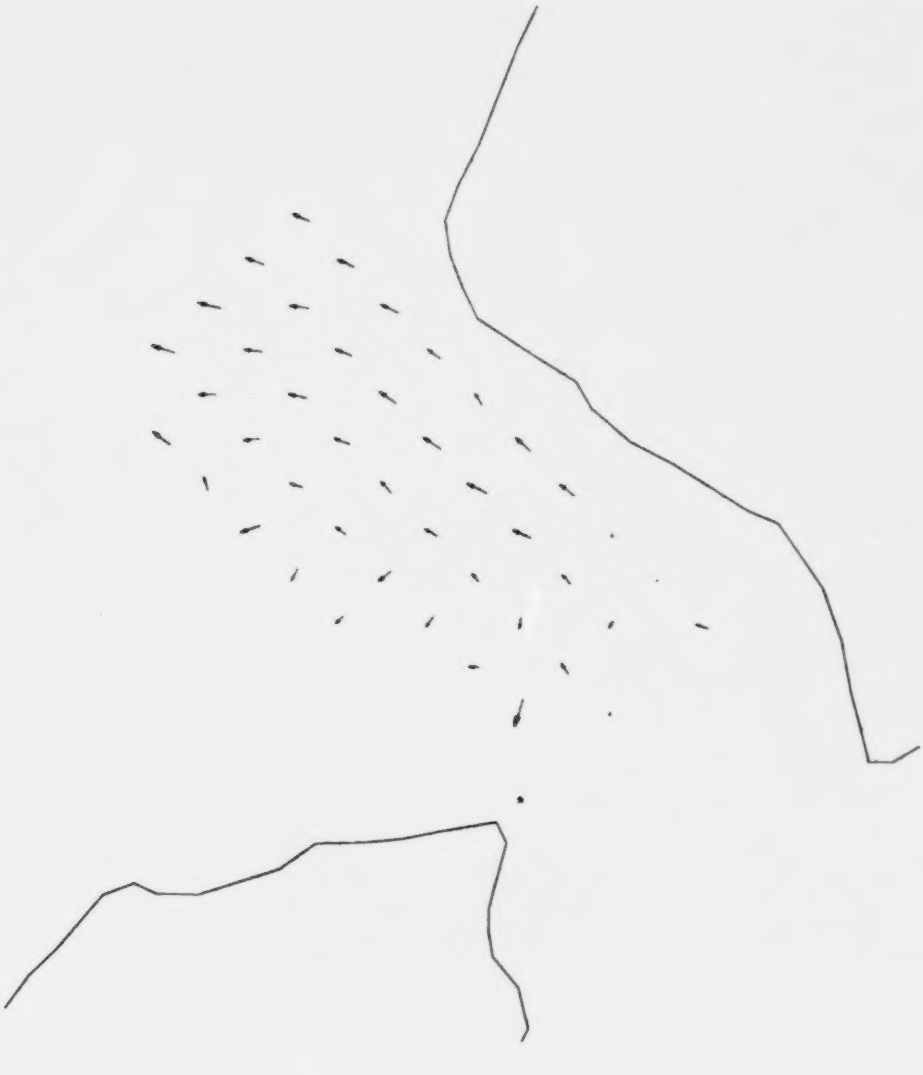
A 4.17



23 AUG 78 15: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [------------]
200 CM/S [------------]
TRUE NORTH ↑

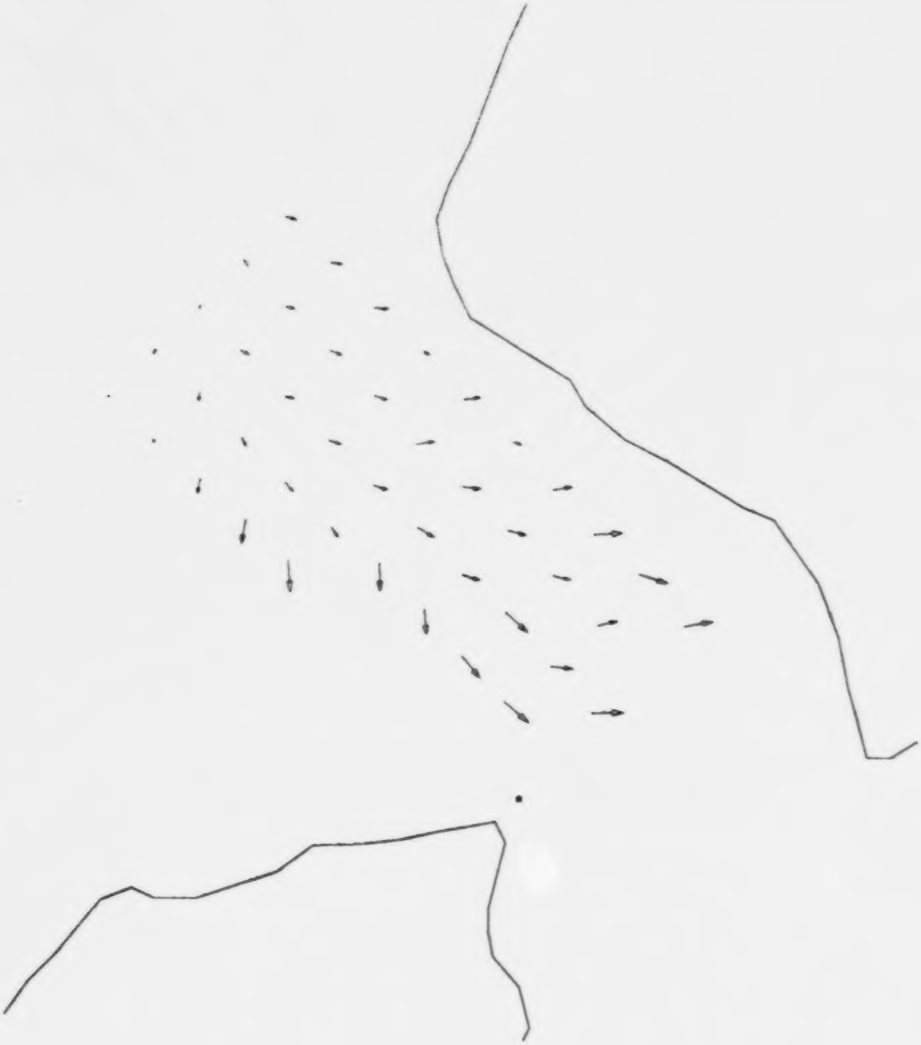
A 4.13



23 AUG 78 16: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [―――――――]
200 CM/S [―――――――]
TRUE NORTH ↑

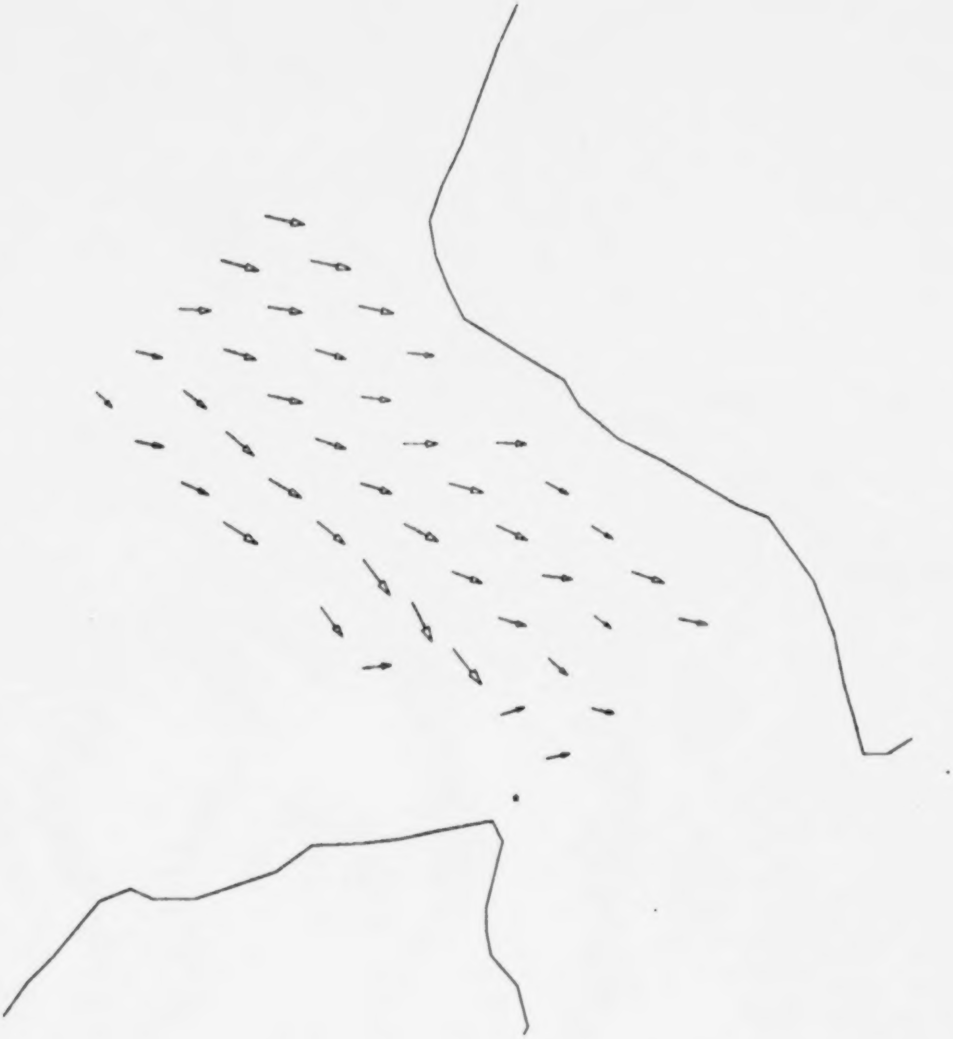
A 4.13



23 AUG 78 17: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [————————]
200 CM/S [————————]
TRUE NORTH ↑

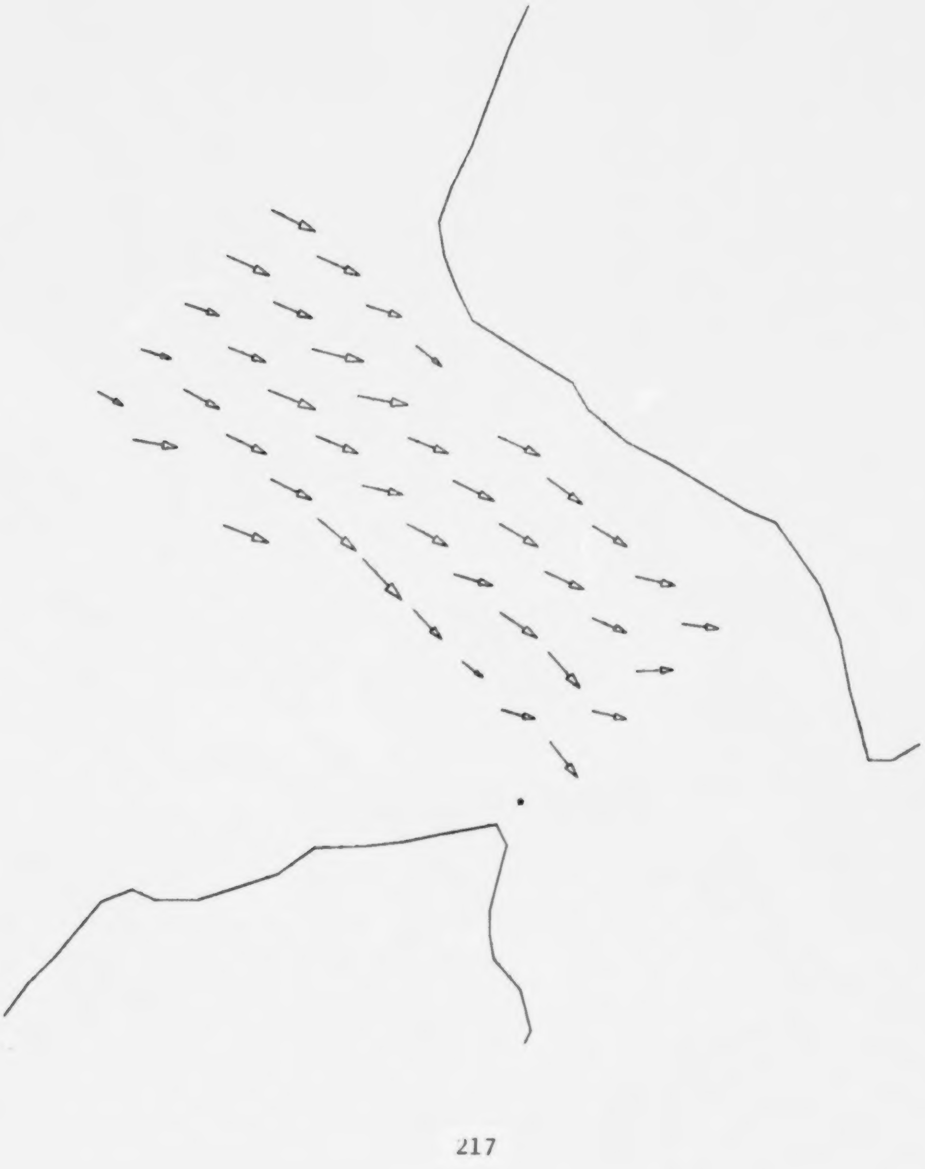
A 4.20



23 AUG 78 18: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

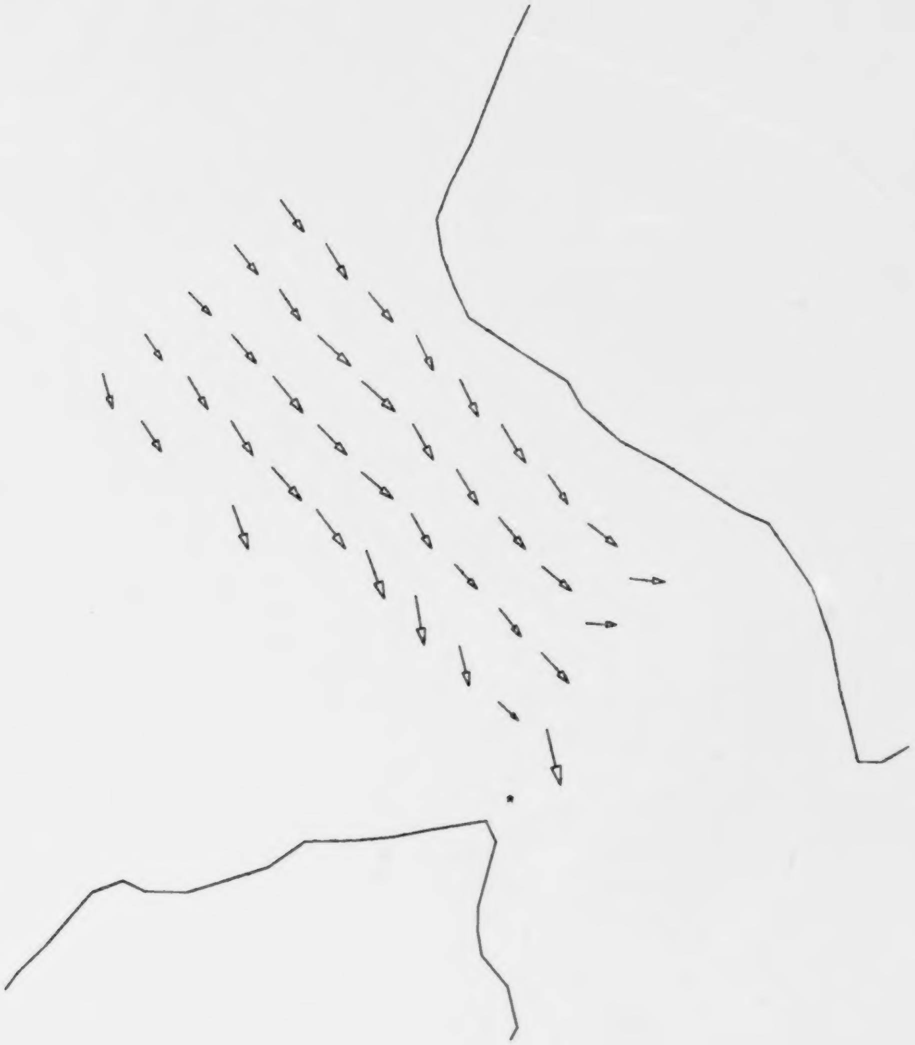
A 4.21



23 AUG 78 19: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [————]
200 CM/S [————]
TRUE NORTH ↑

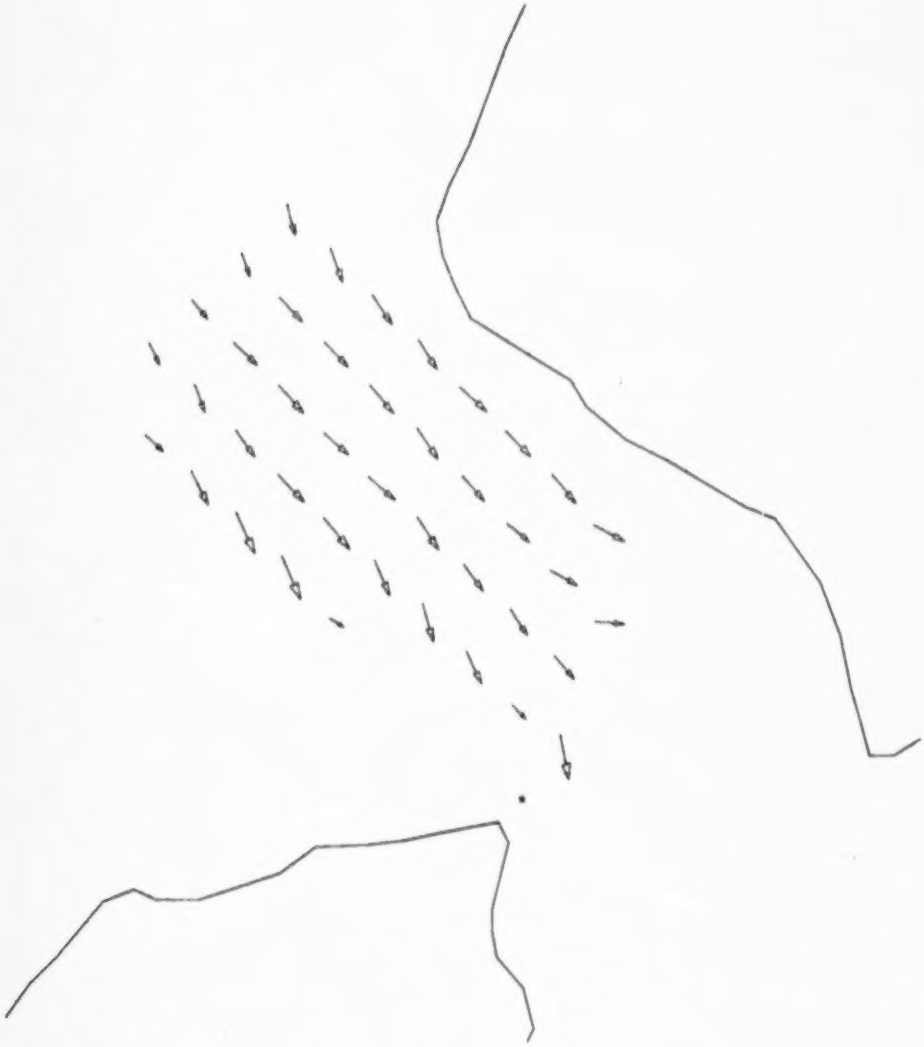
A 4.22

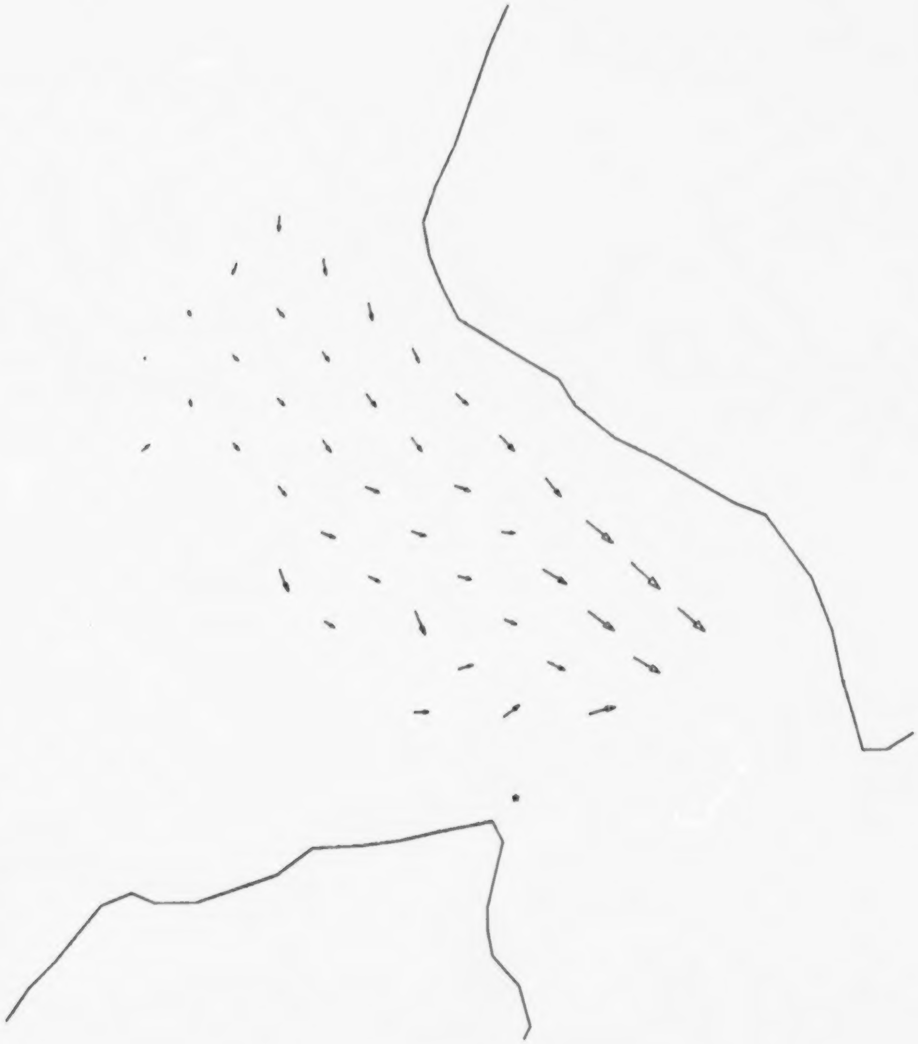


23 AUG 78 20: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [--------------]
200 CM/S [--------------]
TRUE NORTH ↑

A 4.23





A 4.24

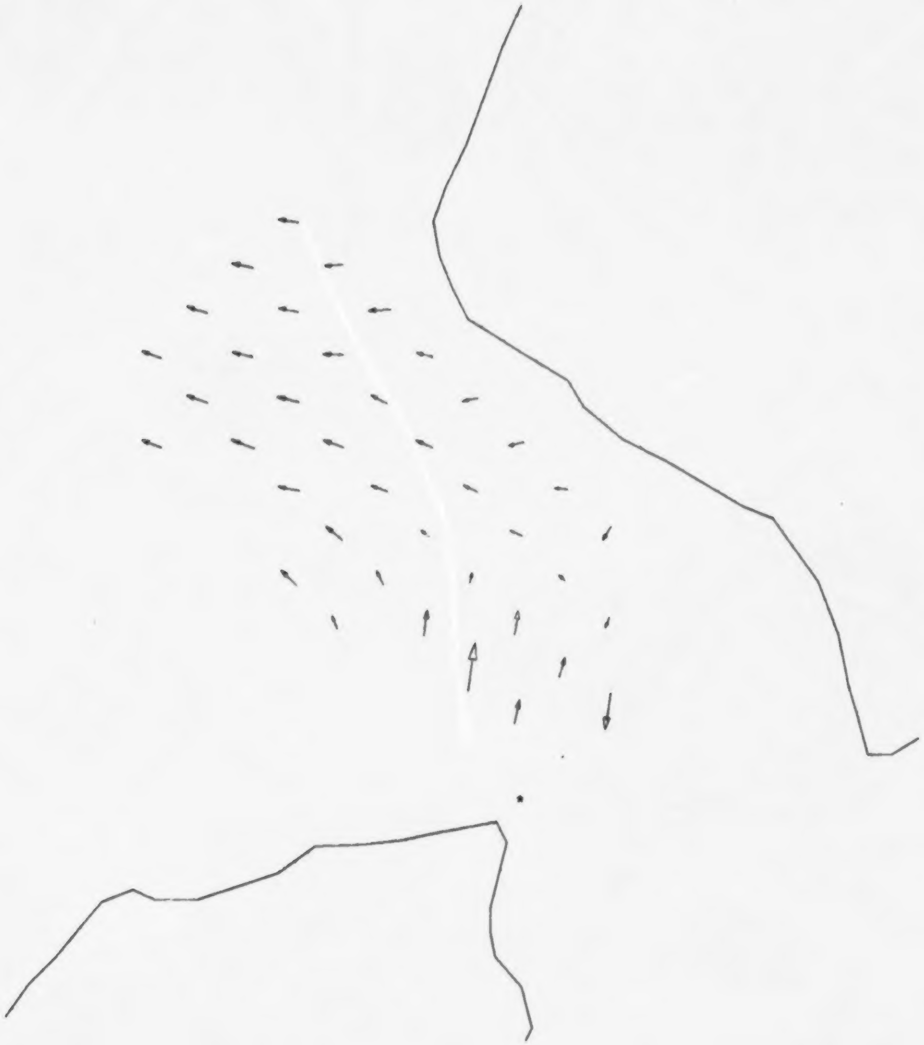
23 AUG 78 21: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

23 AUG 78 22: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

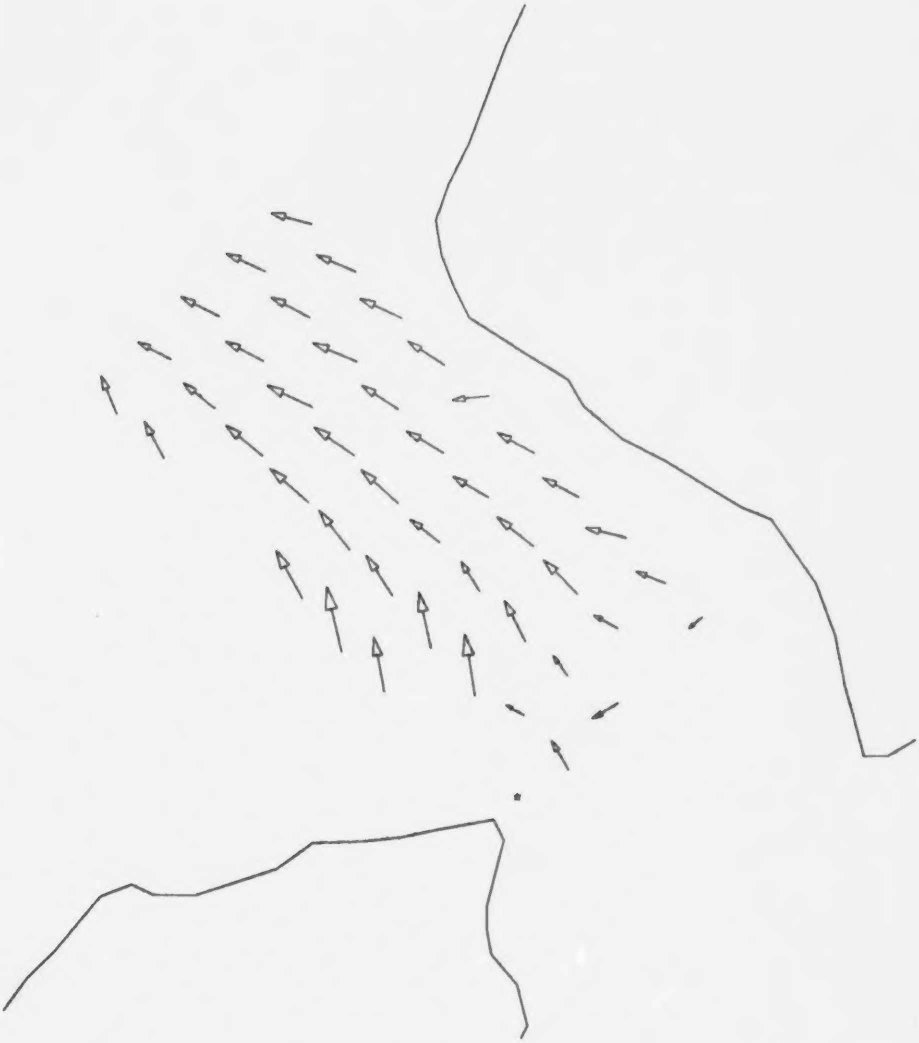
A 4.25



23 AUG 78 23: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.26

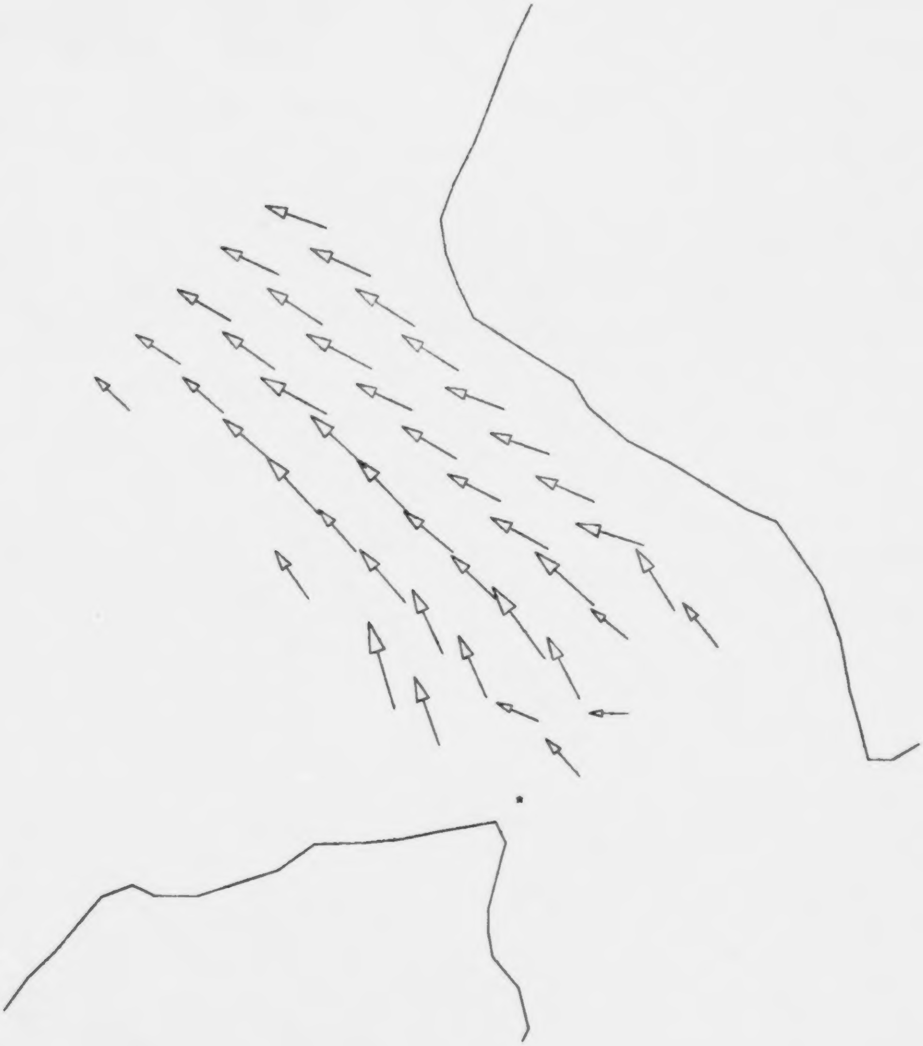


24 AUG 78 0: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.27

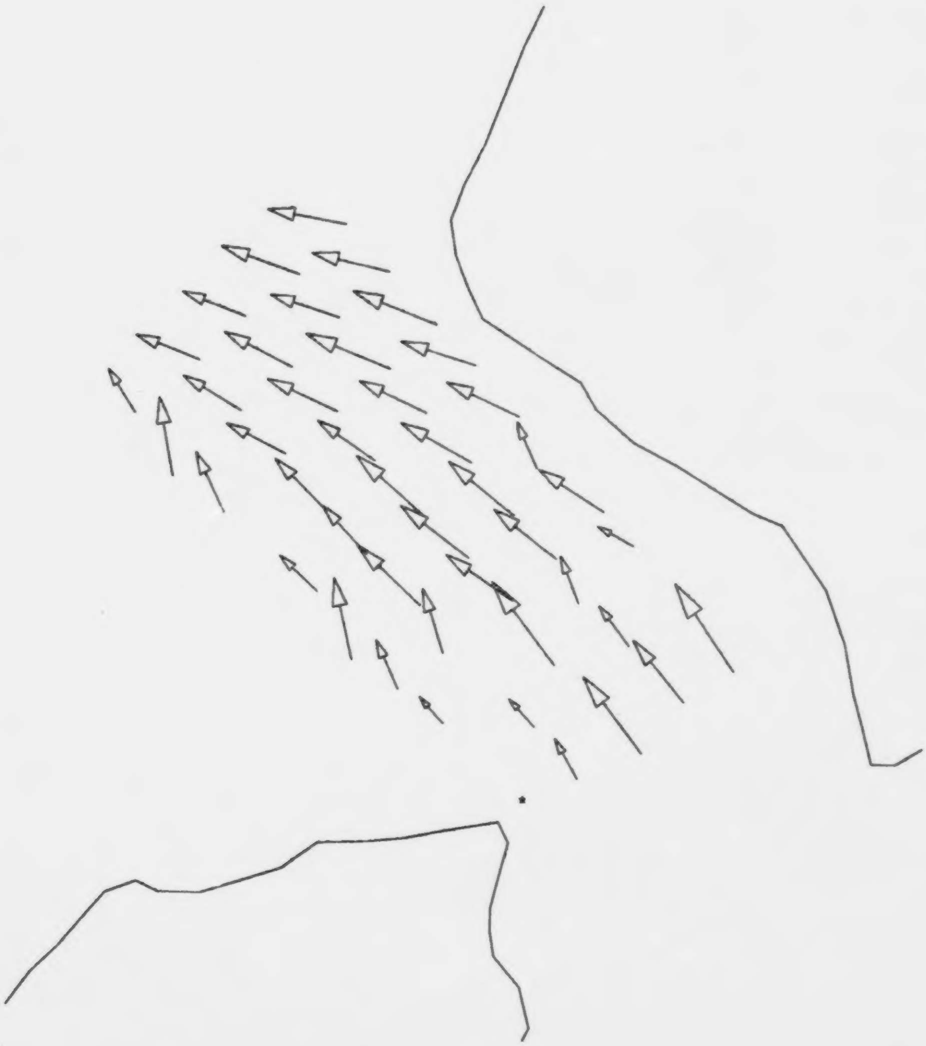


24 AUG 78   1: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

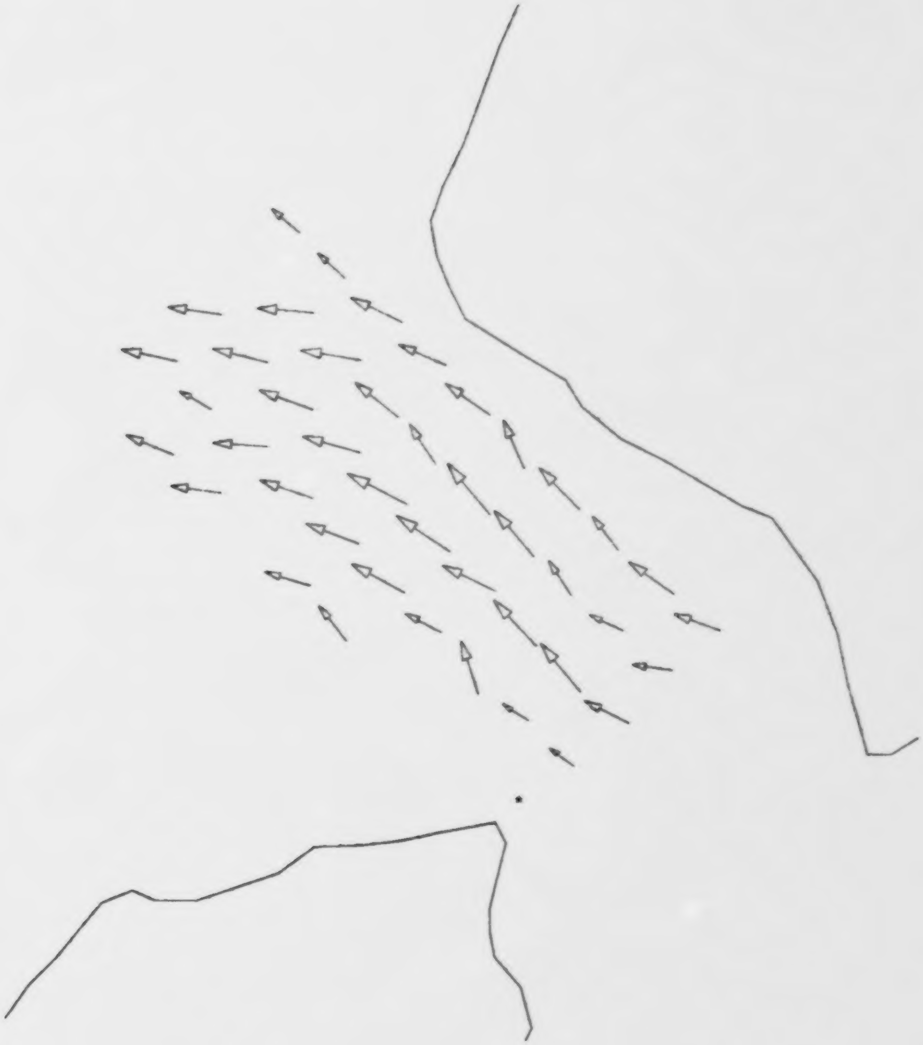
A 4.28



24 AUG 78   2: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

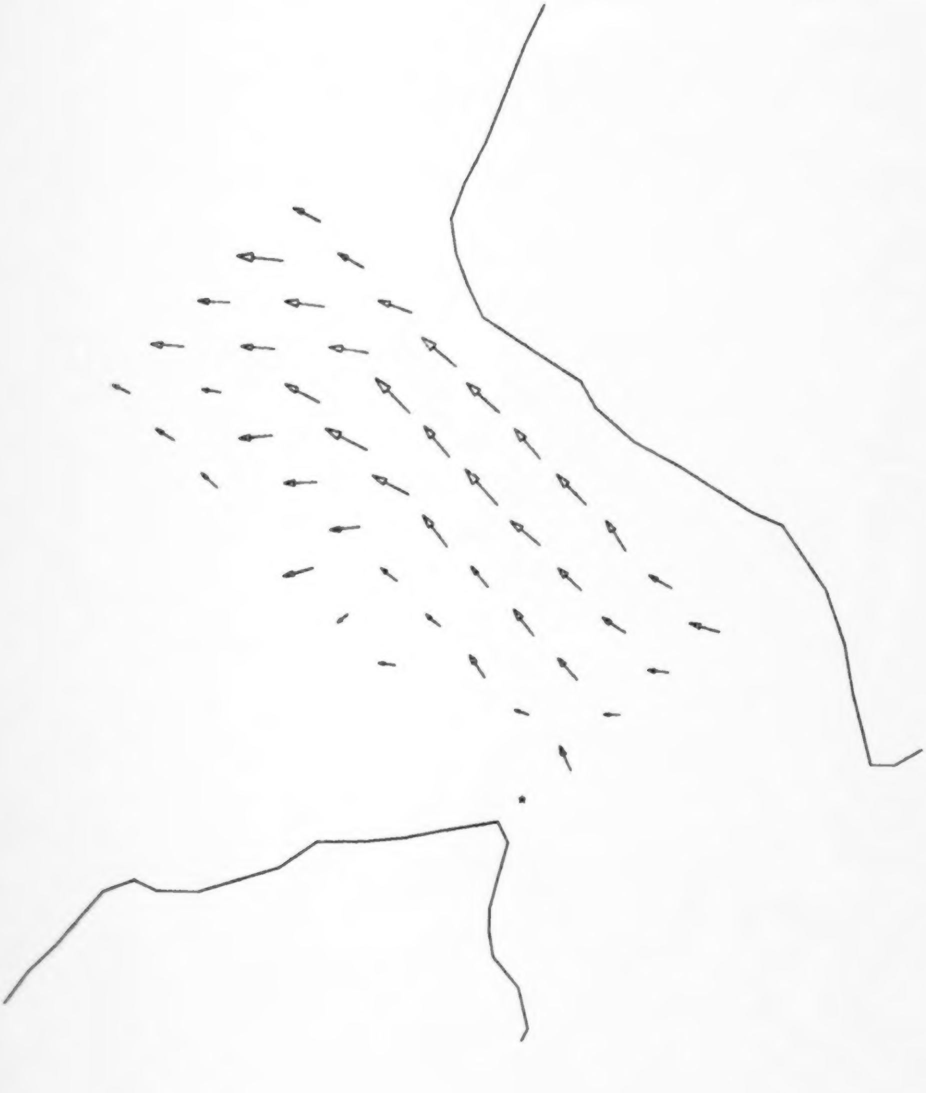
A 4.29



24 AUG 78   3: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [————————]
200 CM/S [————————]
TRUE NORTH ↑

A 4.30

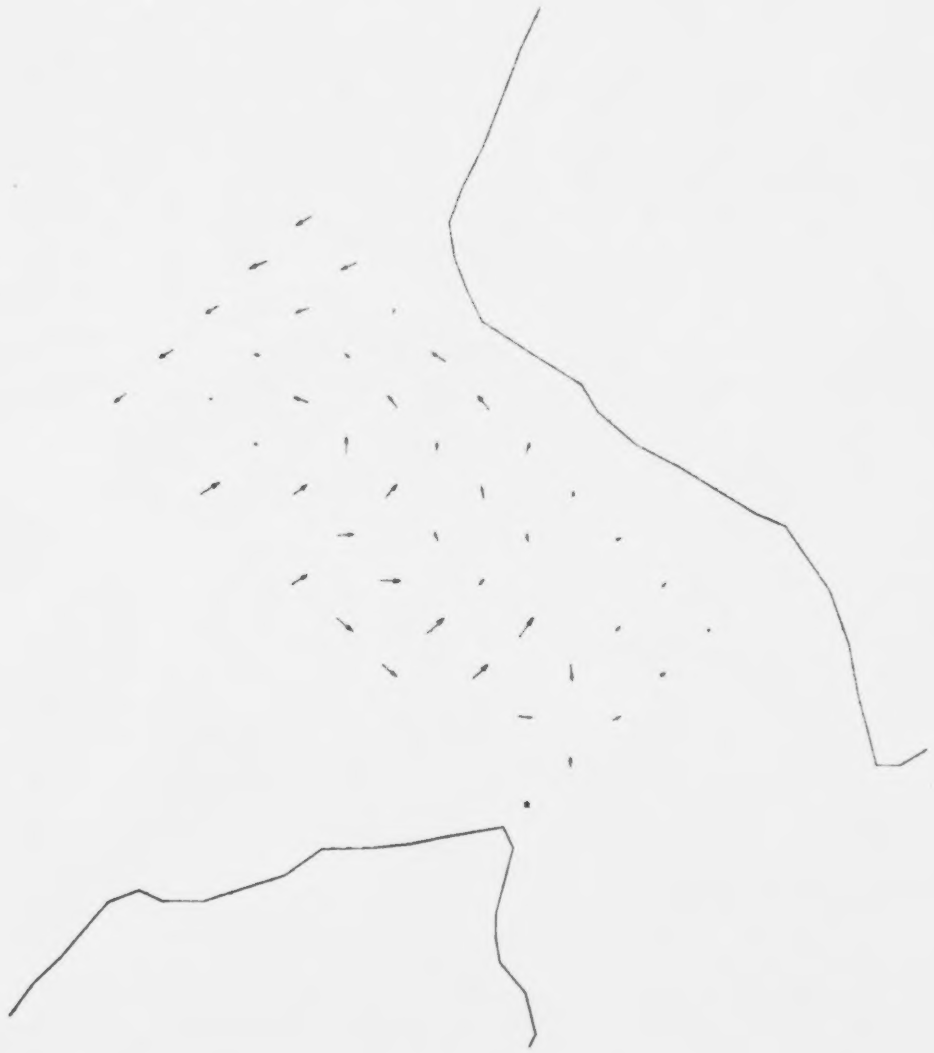


24 AUG 78 4: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

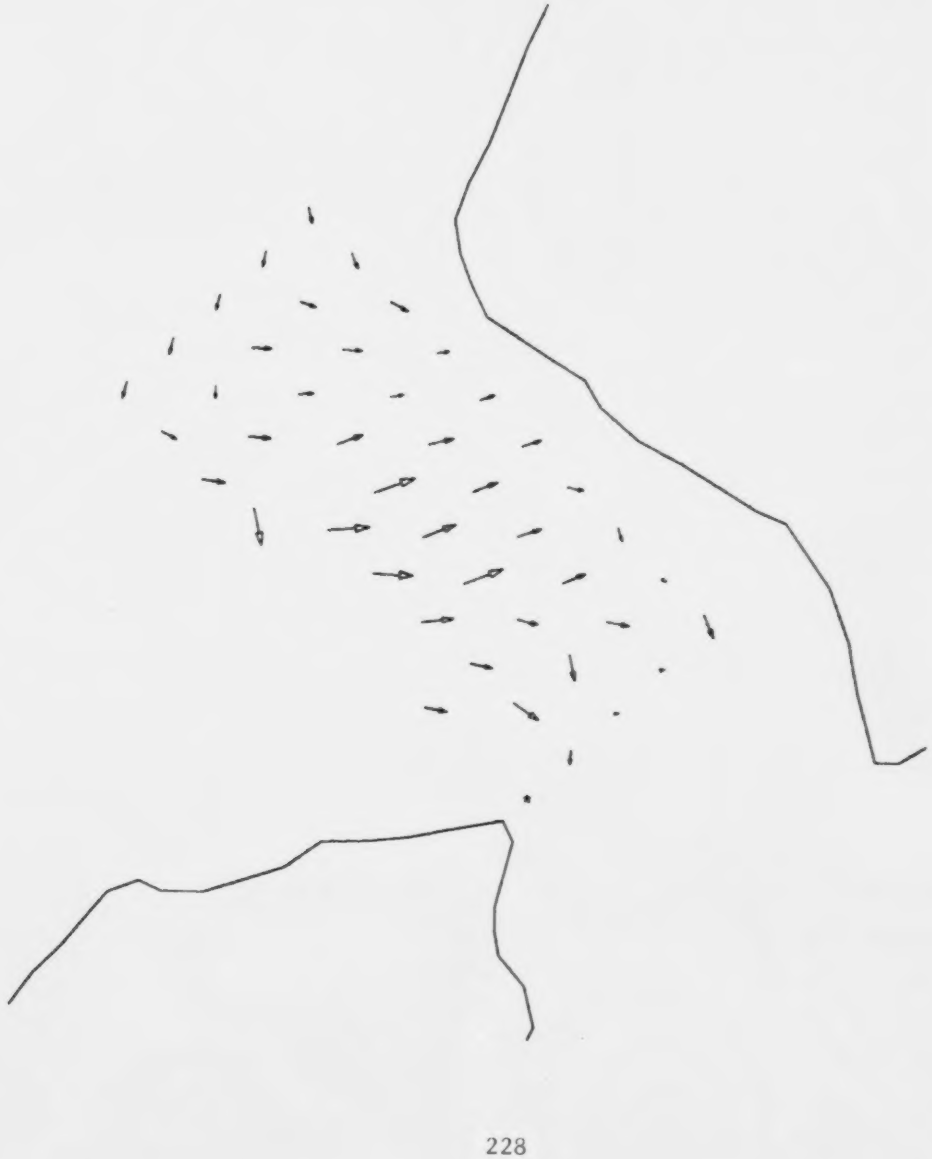
A 4.31



24 AUG 78   5: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.32

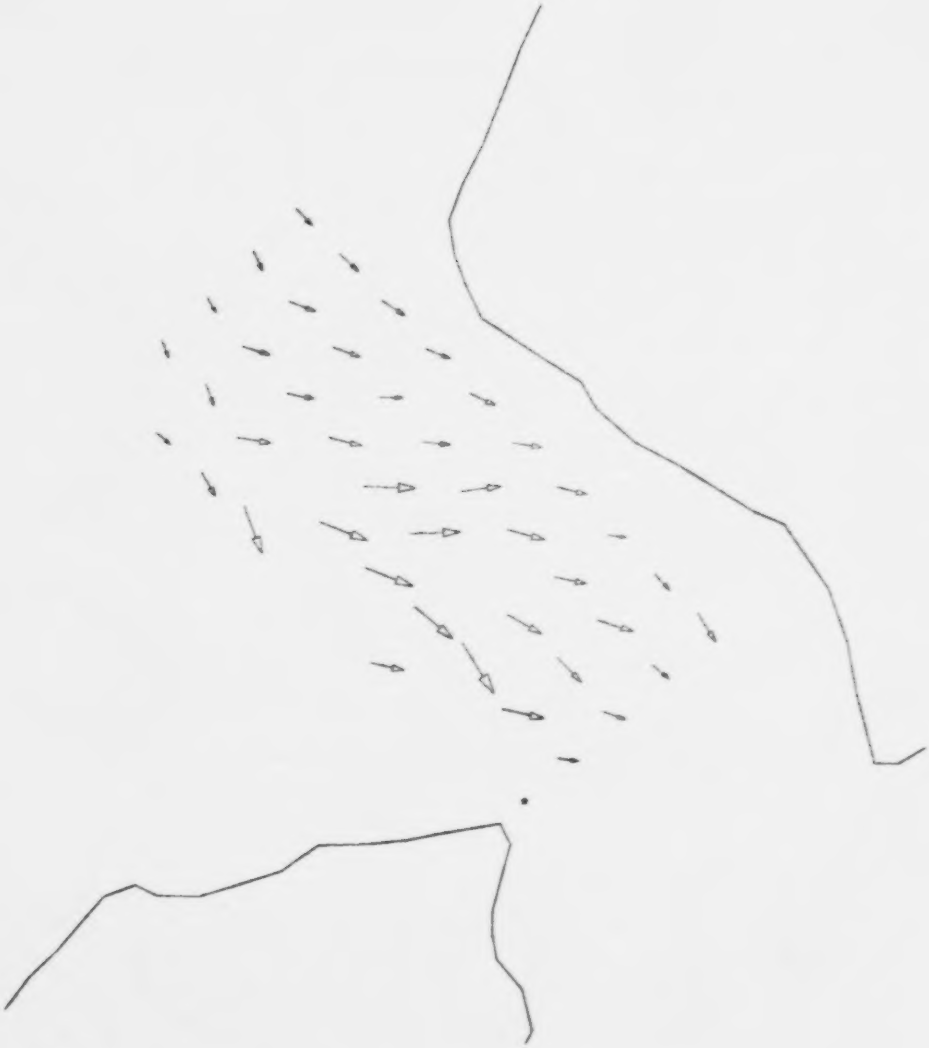


24 AUG 78 6: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [————————]
200 CM/S [————————]

TRUE NORTH ↑

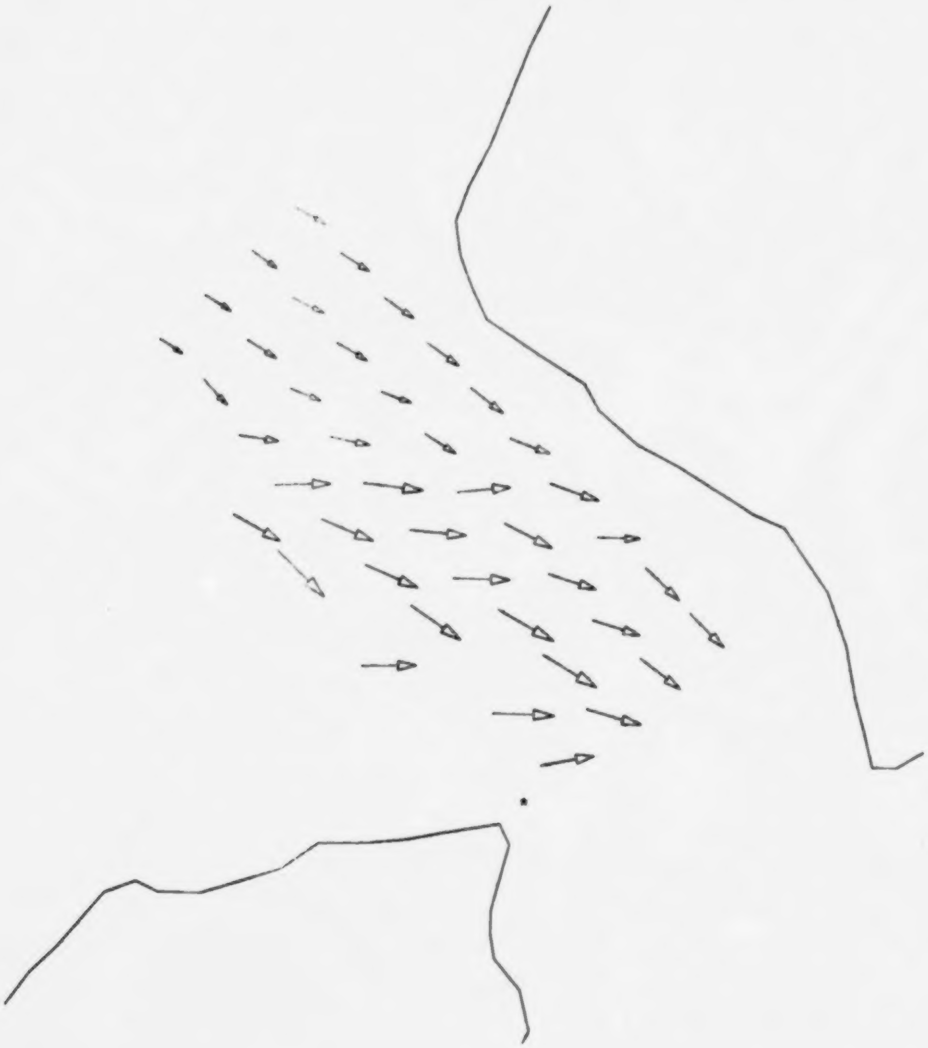
A 4.33



24 AUG 78 7: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.34

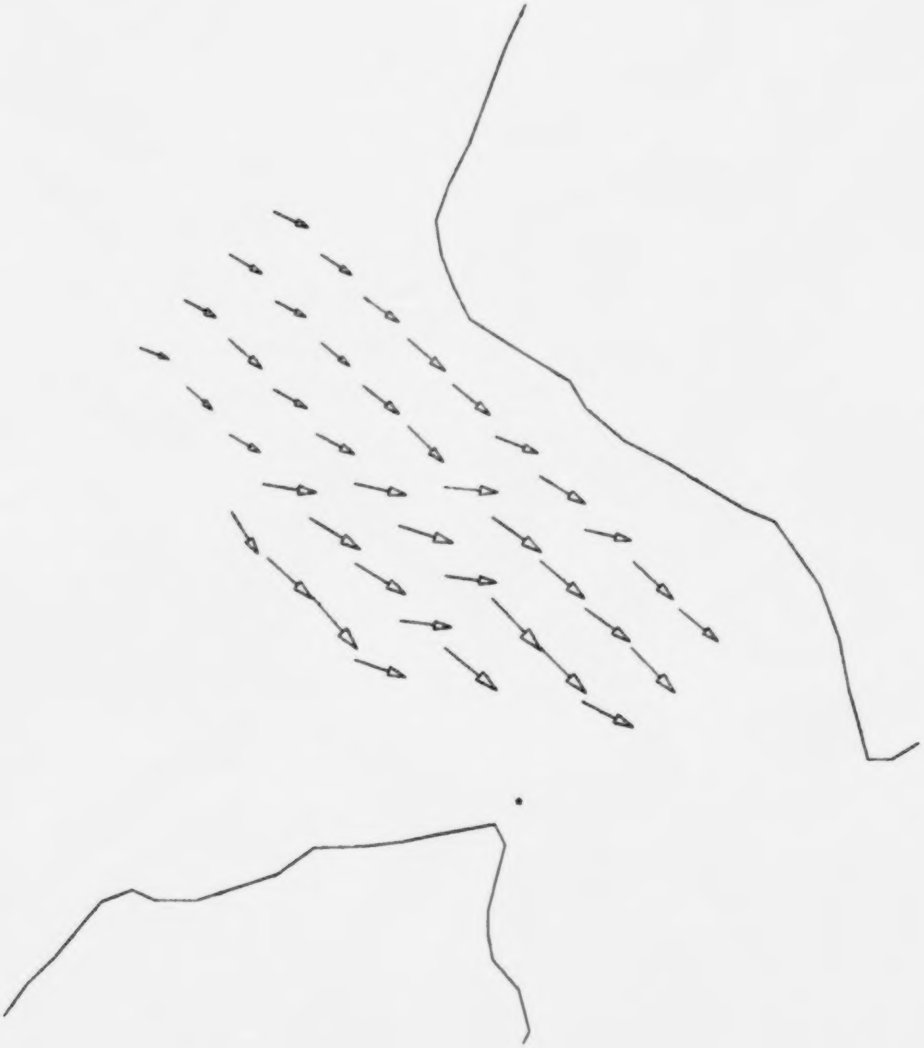


24 AUG 78 8: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

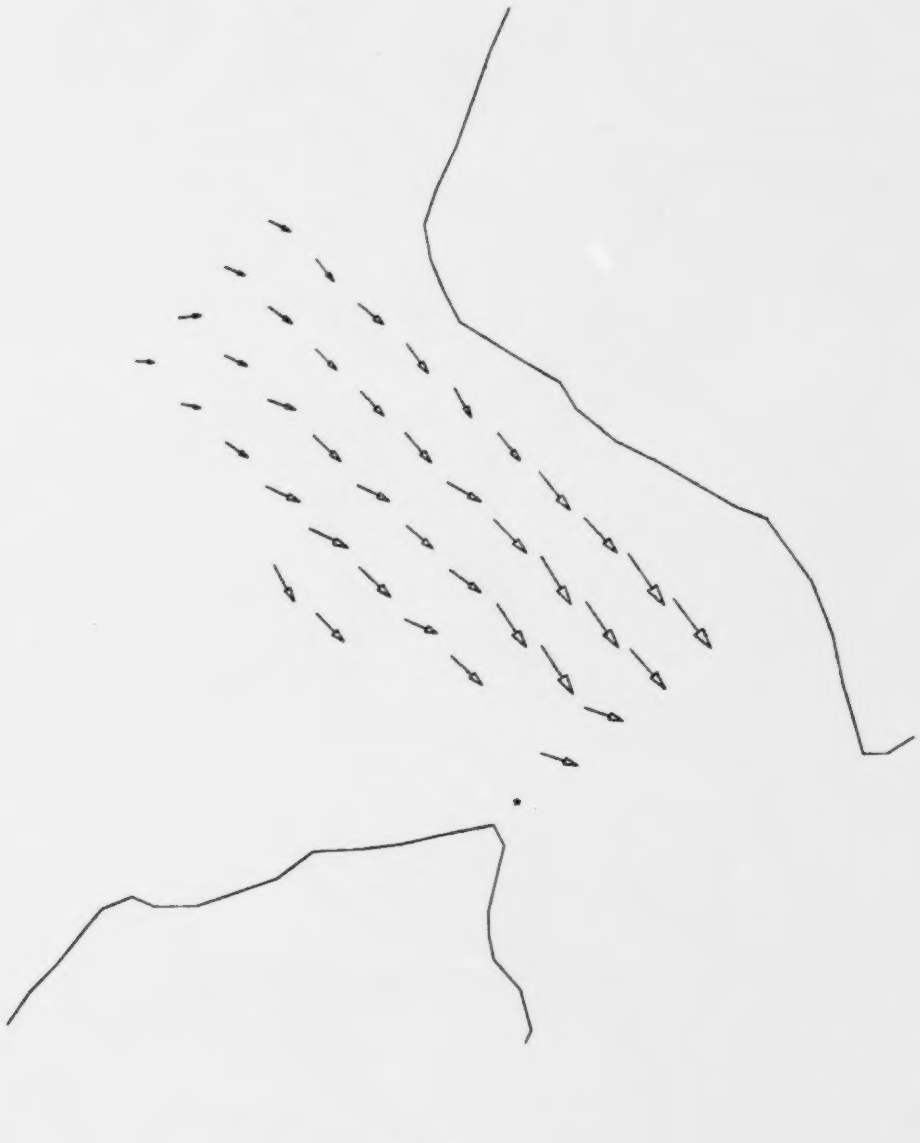
A 4.35



24 AUG 78 9: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.36

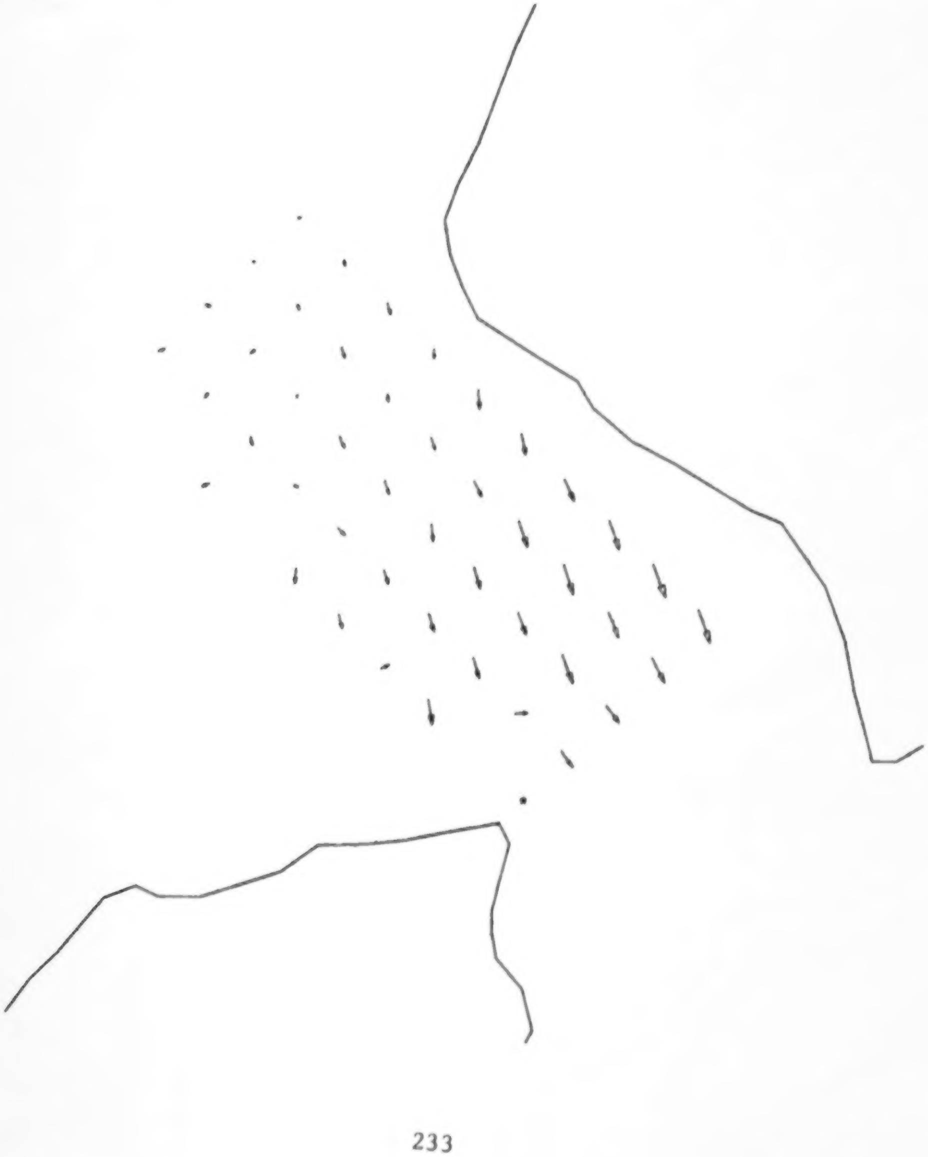


24 AUG 78 10: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.37

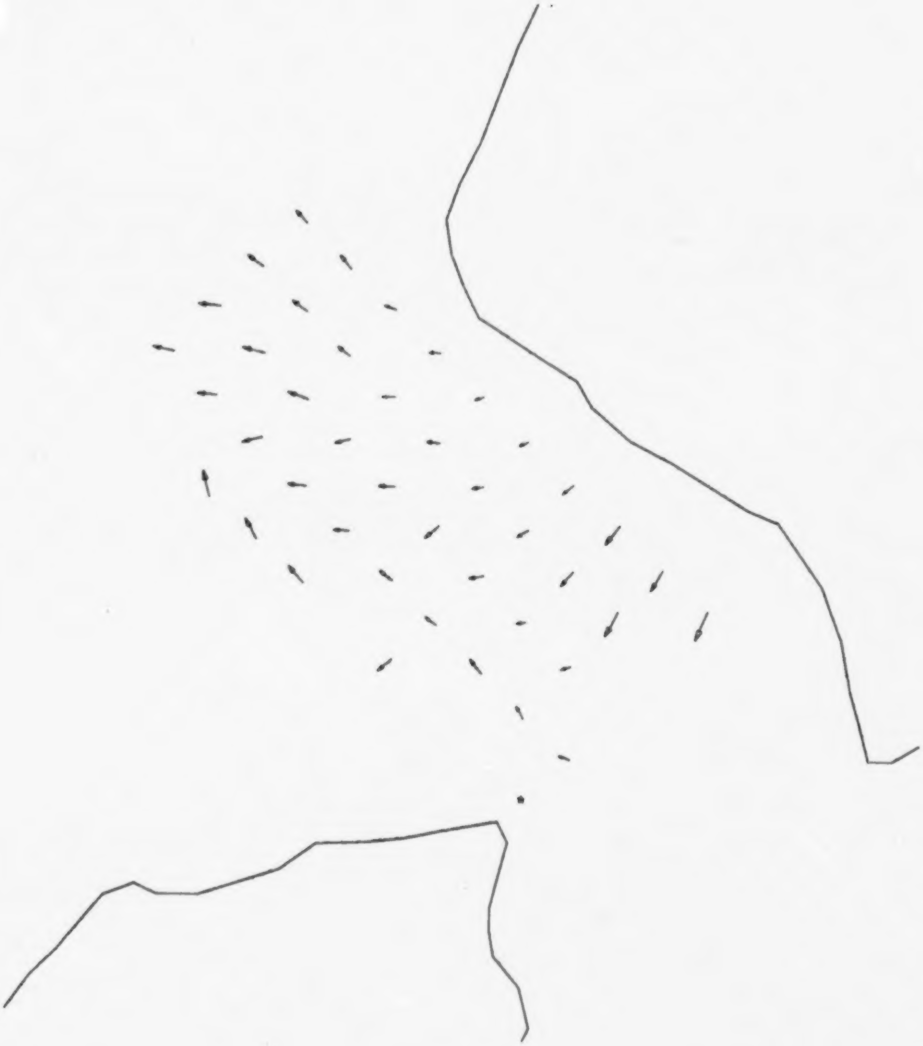


24 AUG 78 11: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.38

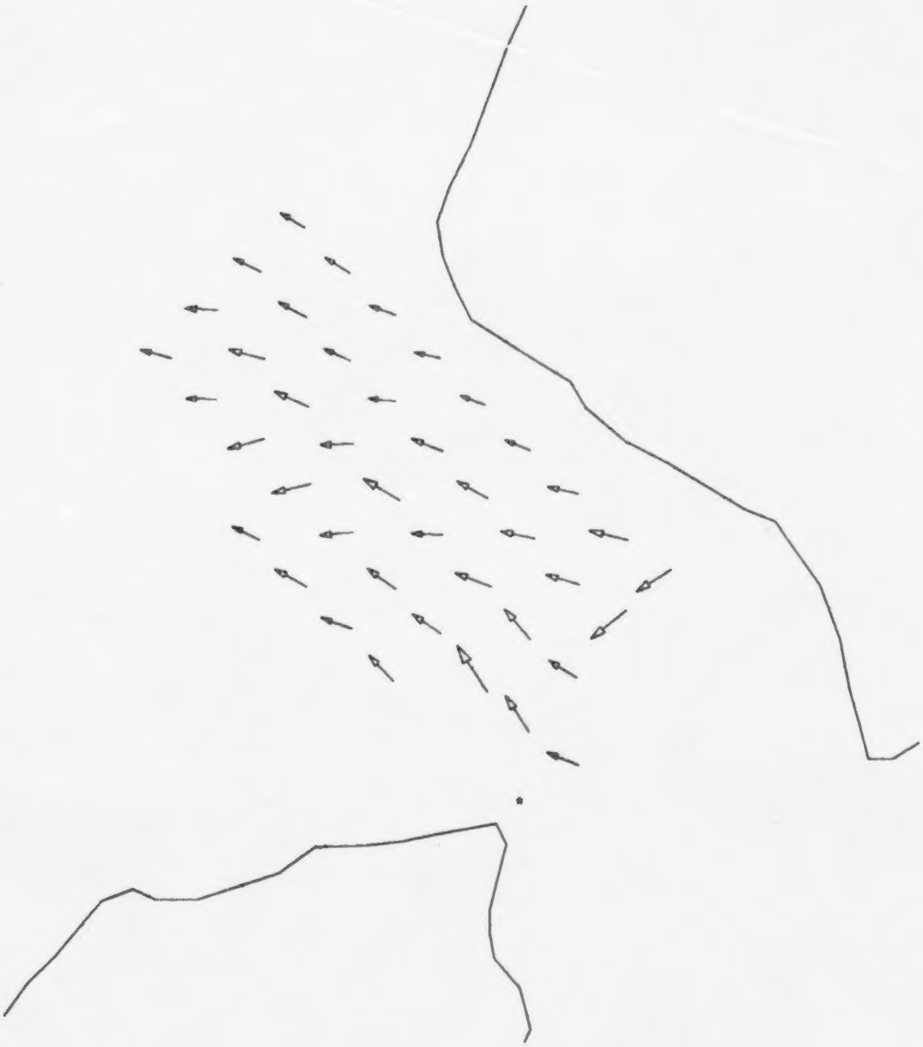


24 AUG 78 12: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [————]
200 CM/S [————]

TRUE NORTH ↑

A 4.39

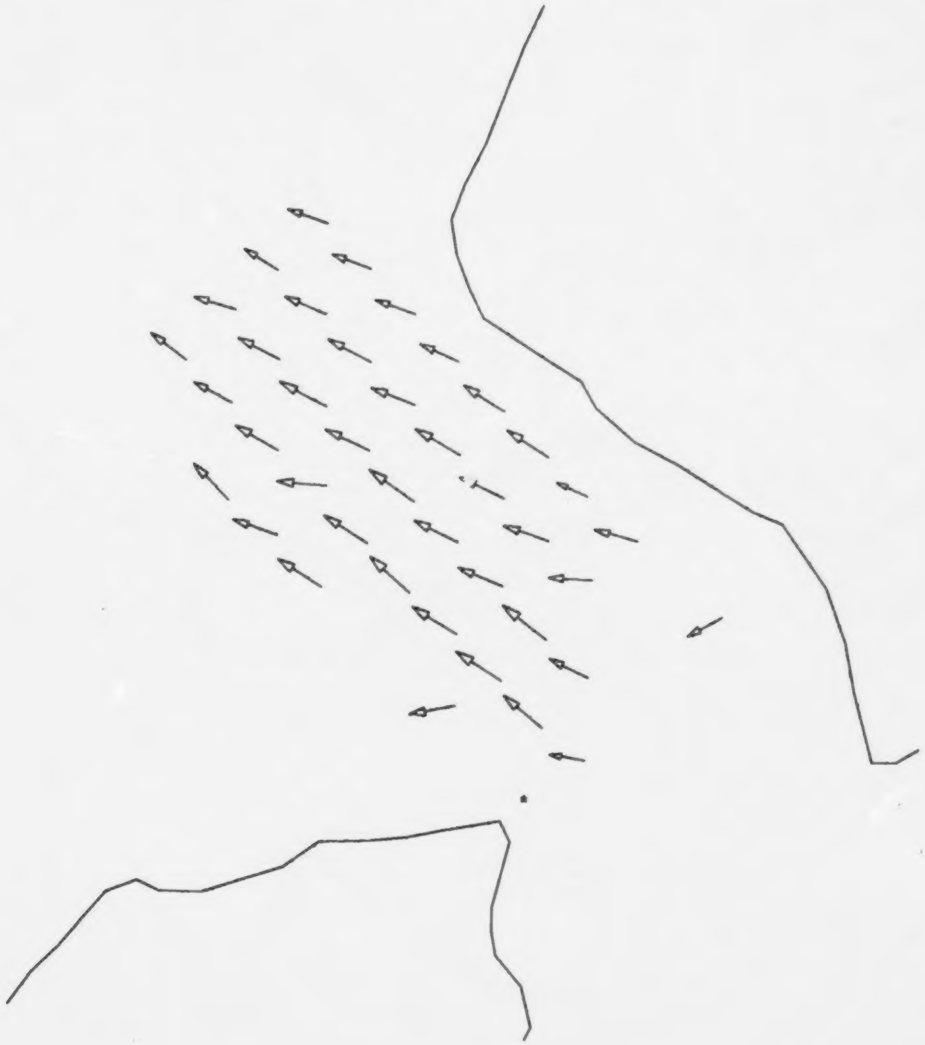


24 AUG 78 13: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [――――――]
200 CM/S [――――――]

TRUE NORTH ↑

A 4.40

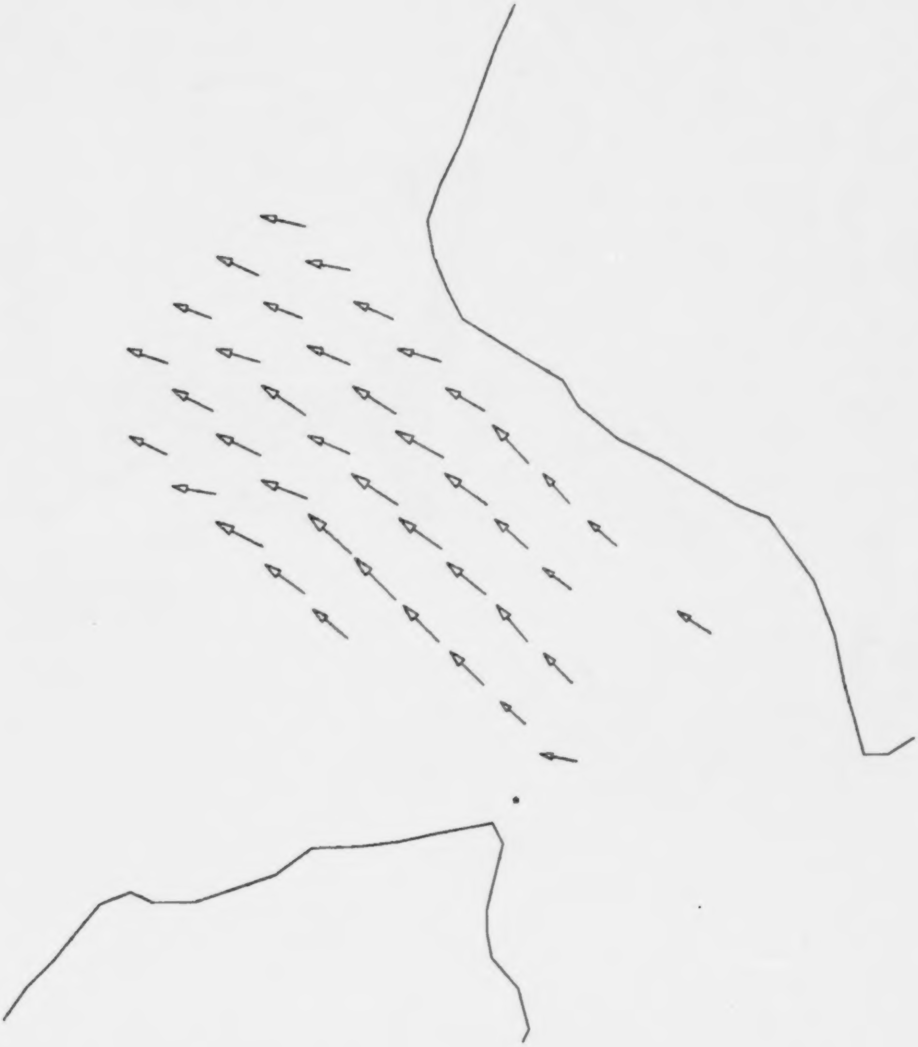


24 AUG 78 14: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.41

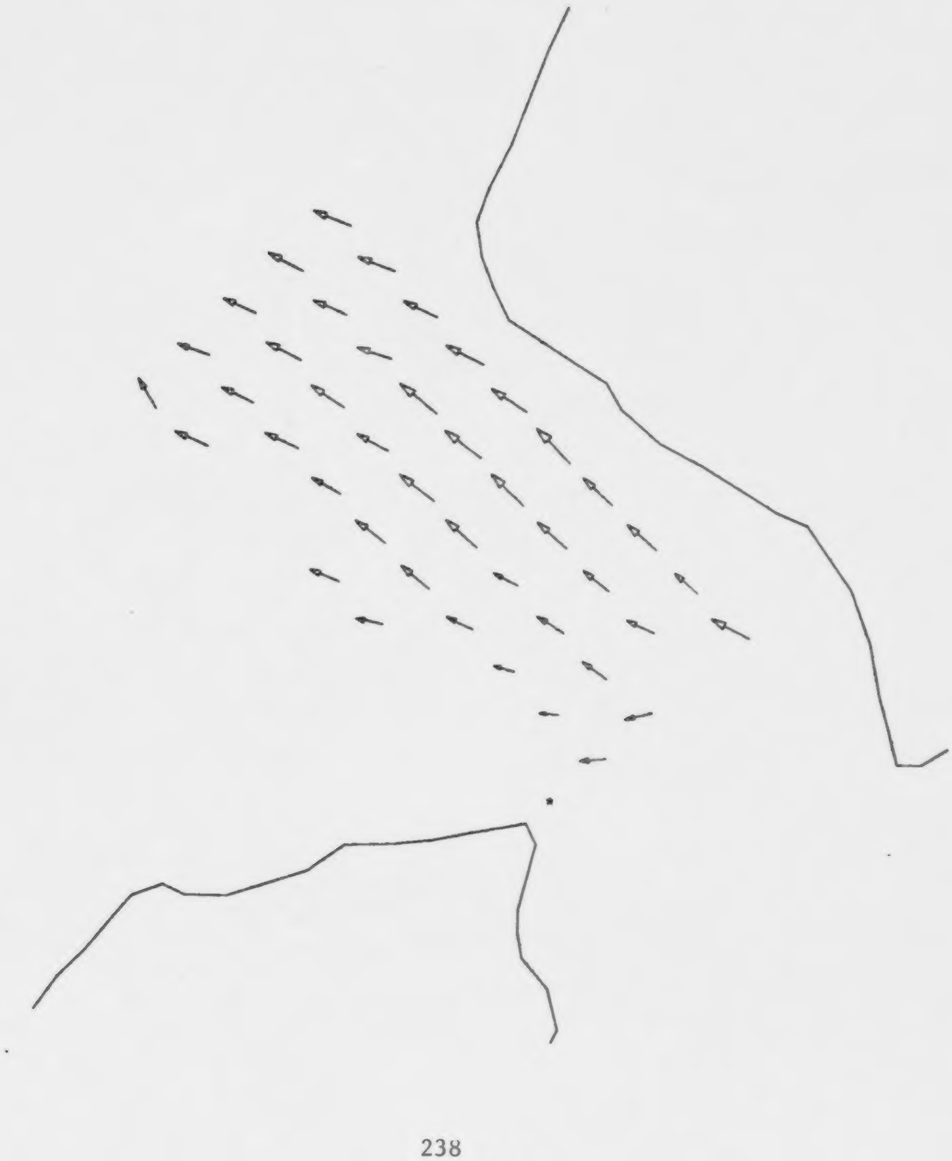


24 AUG 78 15: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [------------]
200 CM/S [------------]

TRUE NORTH ↑

A 4.42

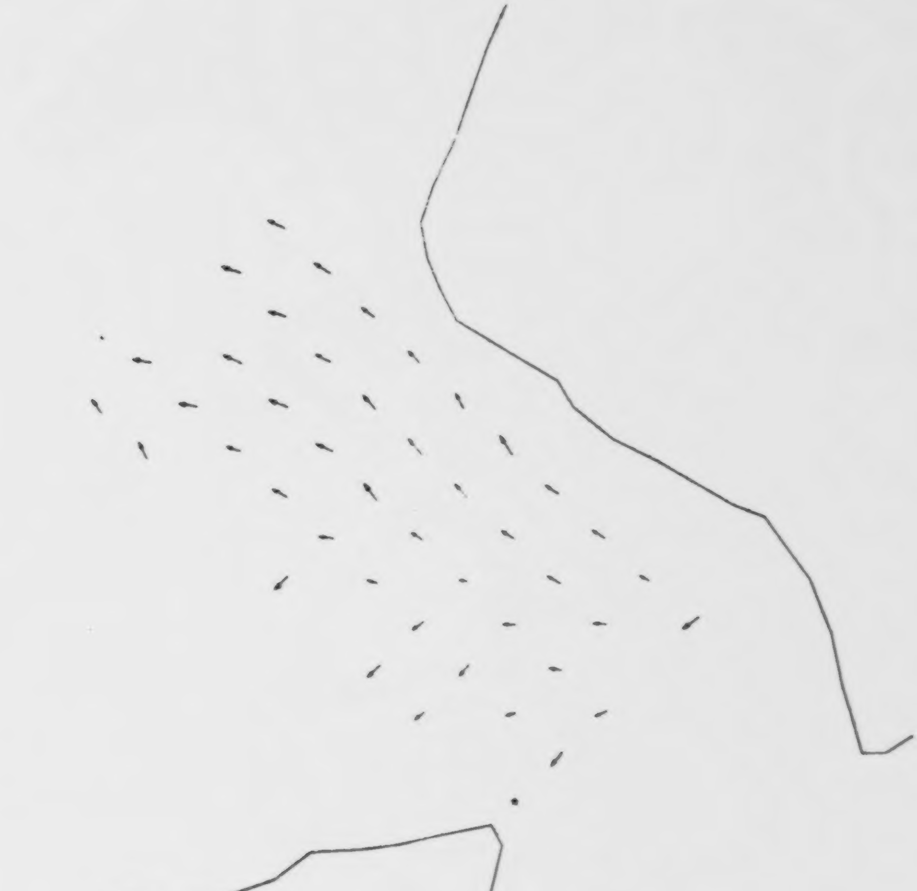


24 AUG 78 16: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

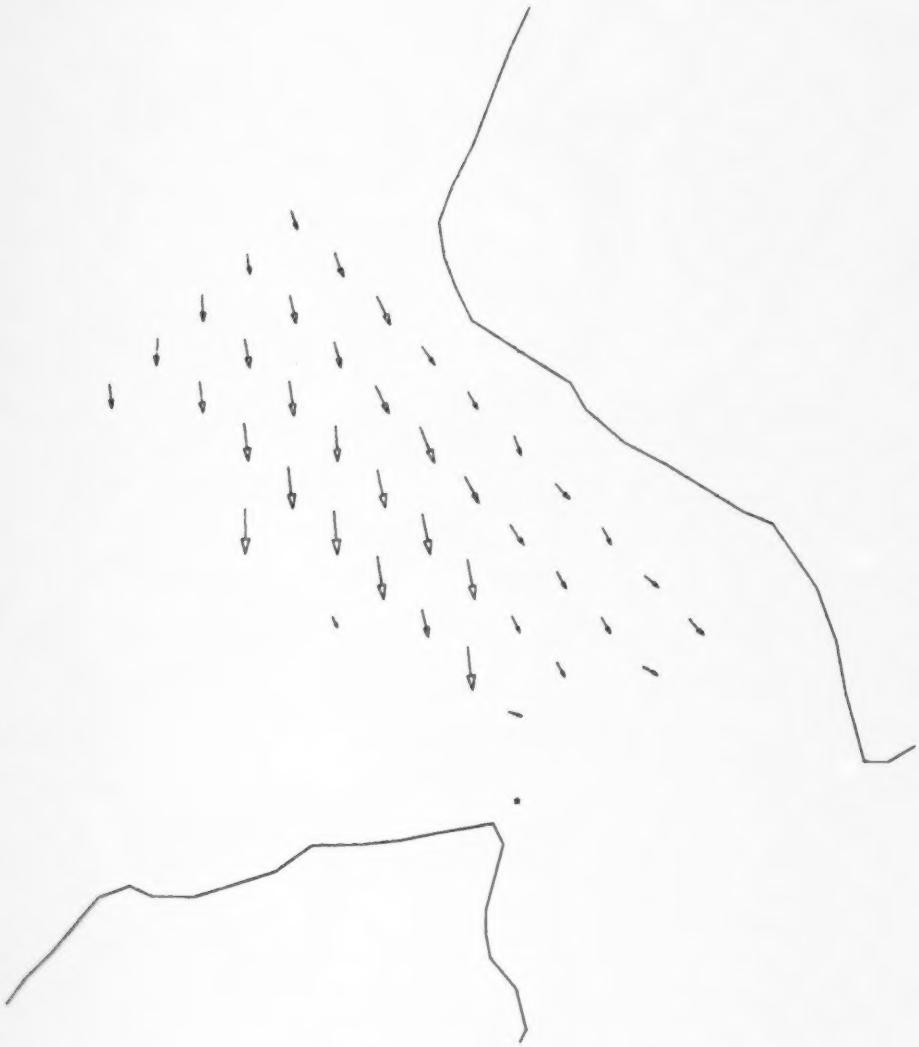
A 4.43



24 AUG 78 17: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [------------]
200 CM/S [------------]
TRUE NORTH ↑

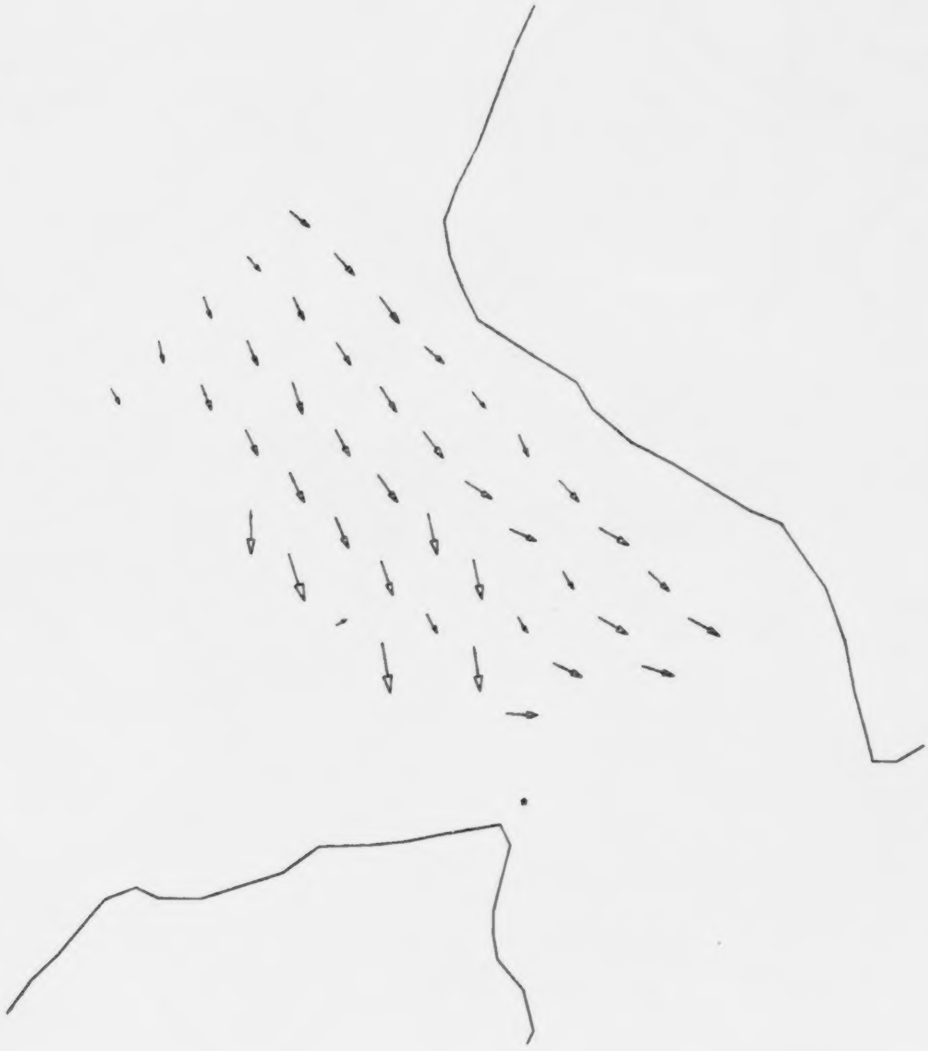
A 4.44



24 AUG 78 18: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

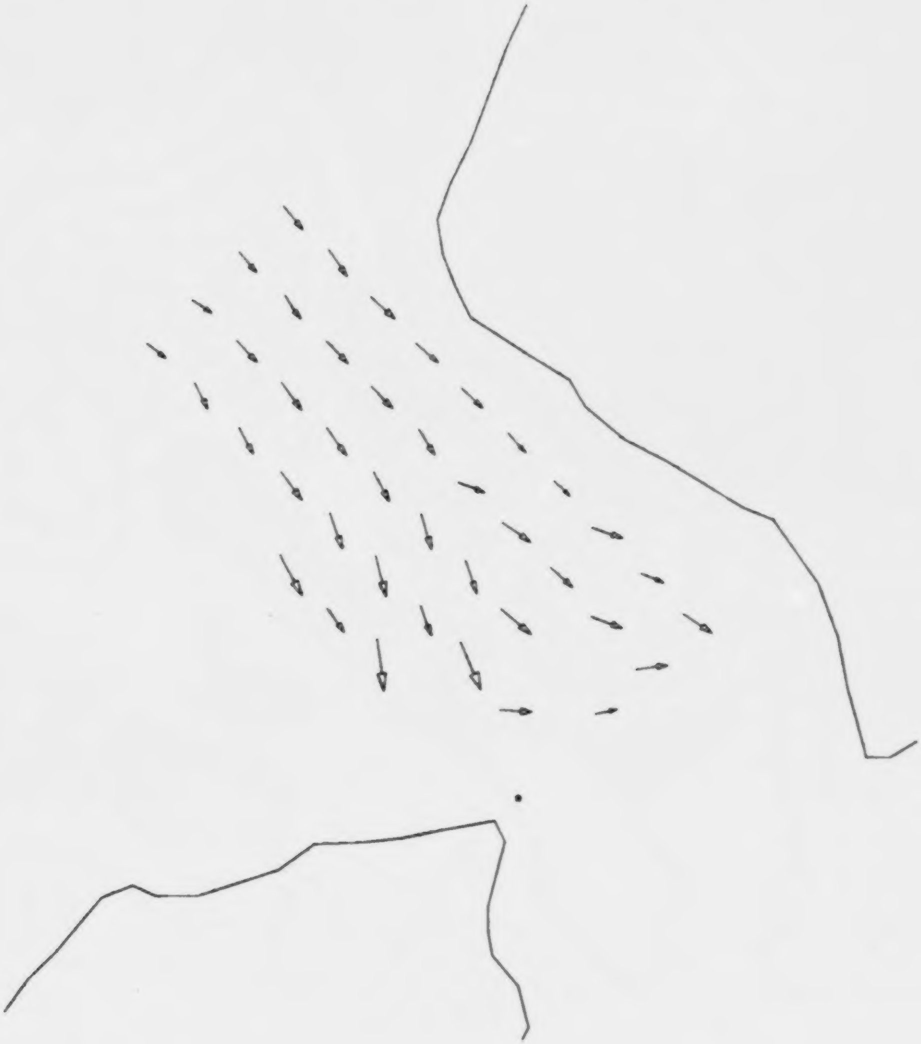
A 4.45



24 AUG 78 19: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [--------------]
200 CM/S [--------------]
TRUE NORTH ↑

A 4.46

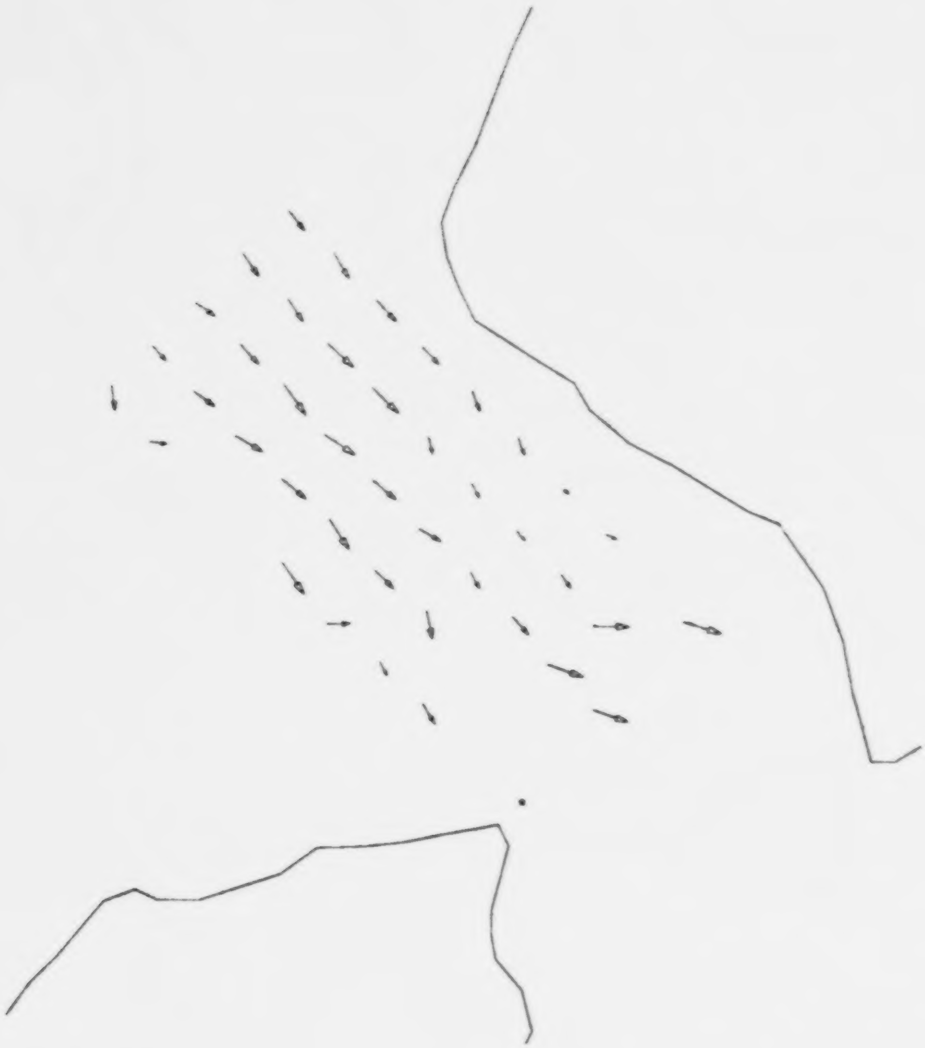


24 AUG 78 20: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.47

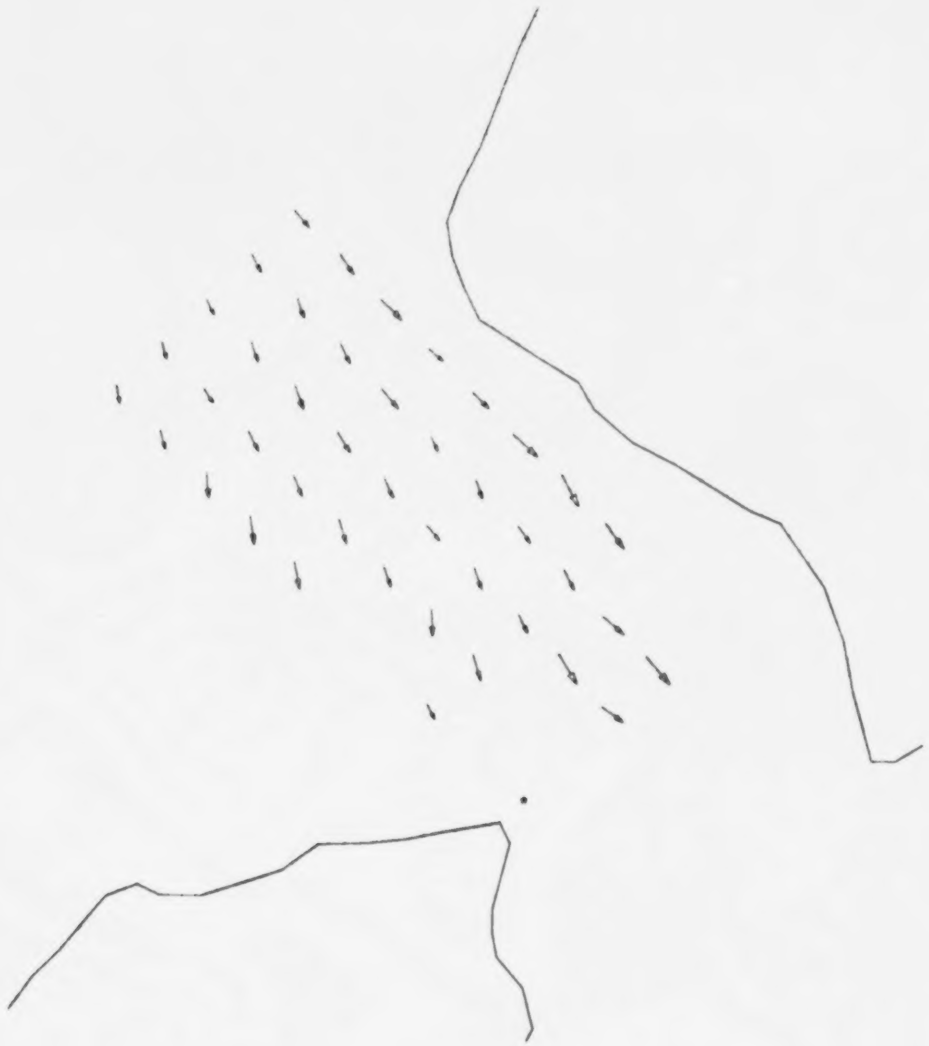


24 AUG 78 21: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.43

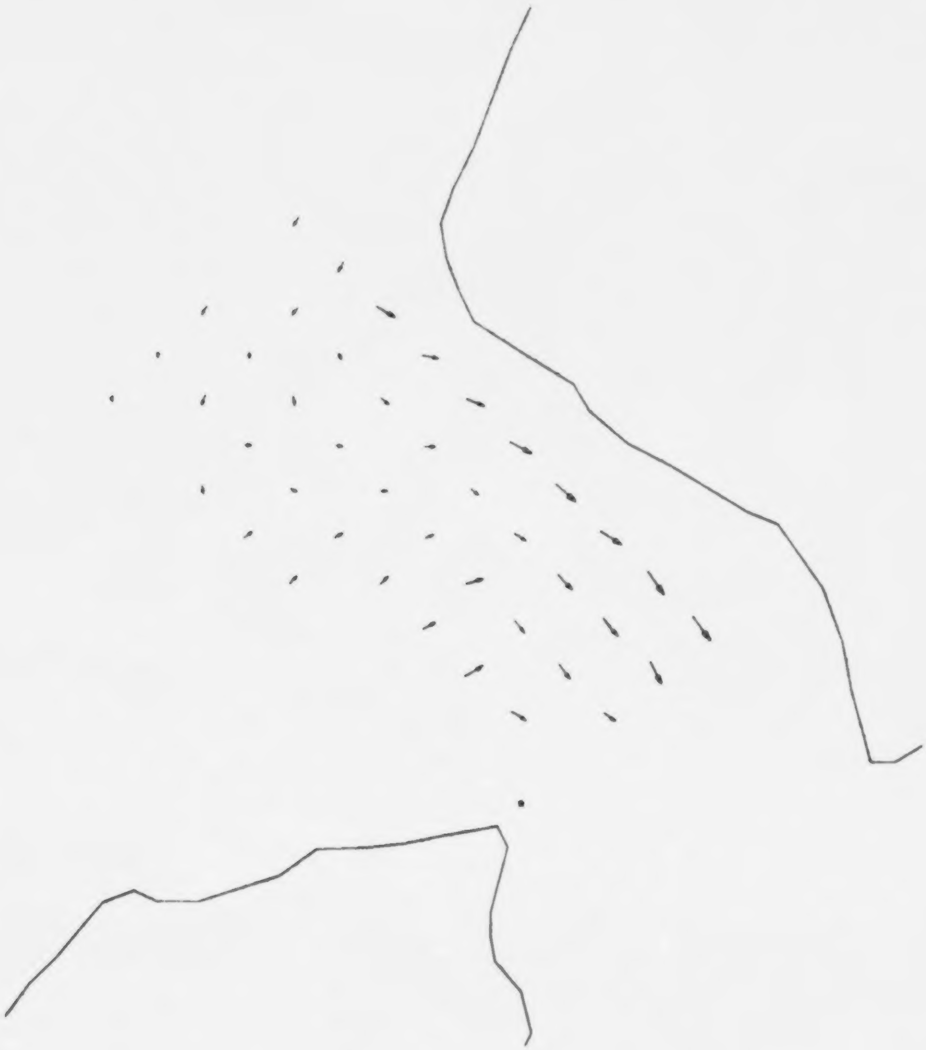


24 AUG 78 22: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

A 4.49

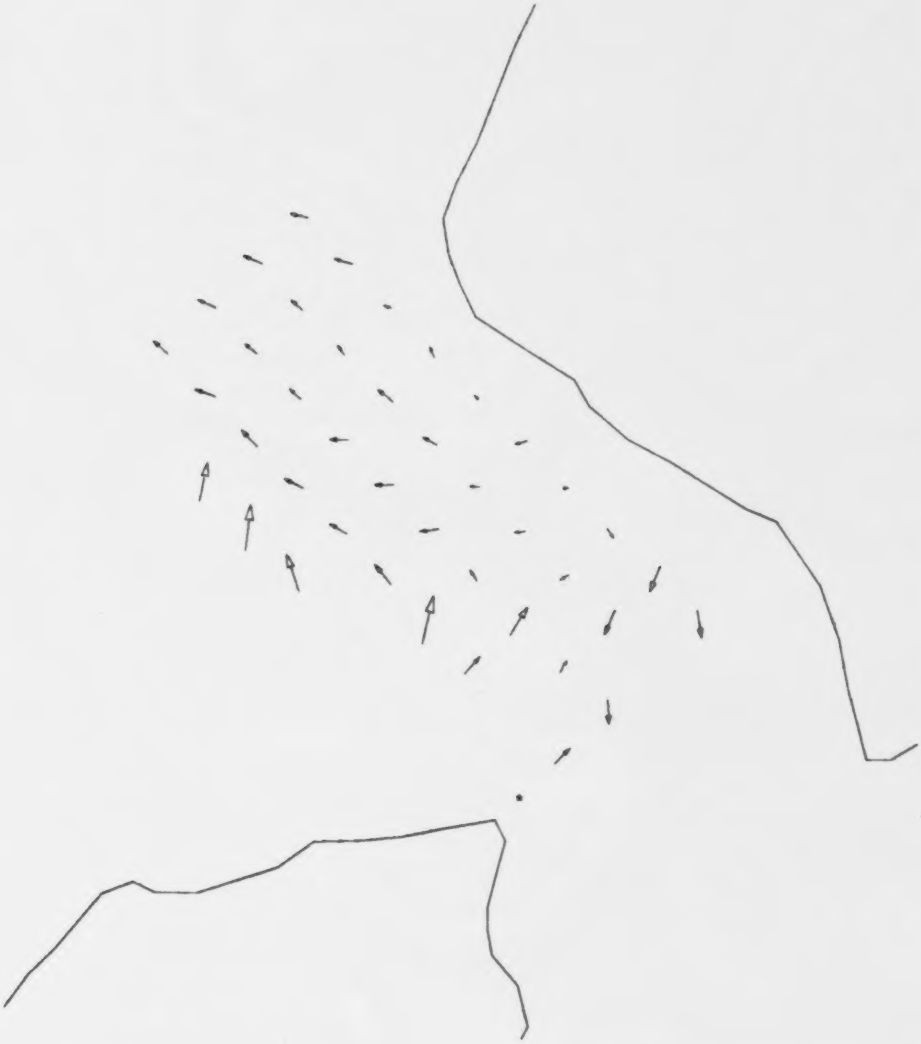


24 AUG 78 23: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [――――――――]
200 CM/S [――――――――]

TRUE NORTH ↑

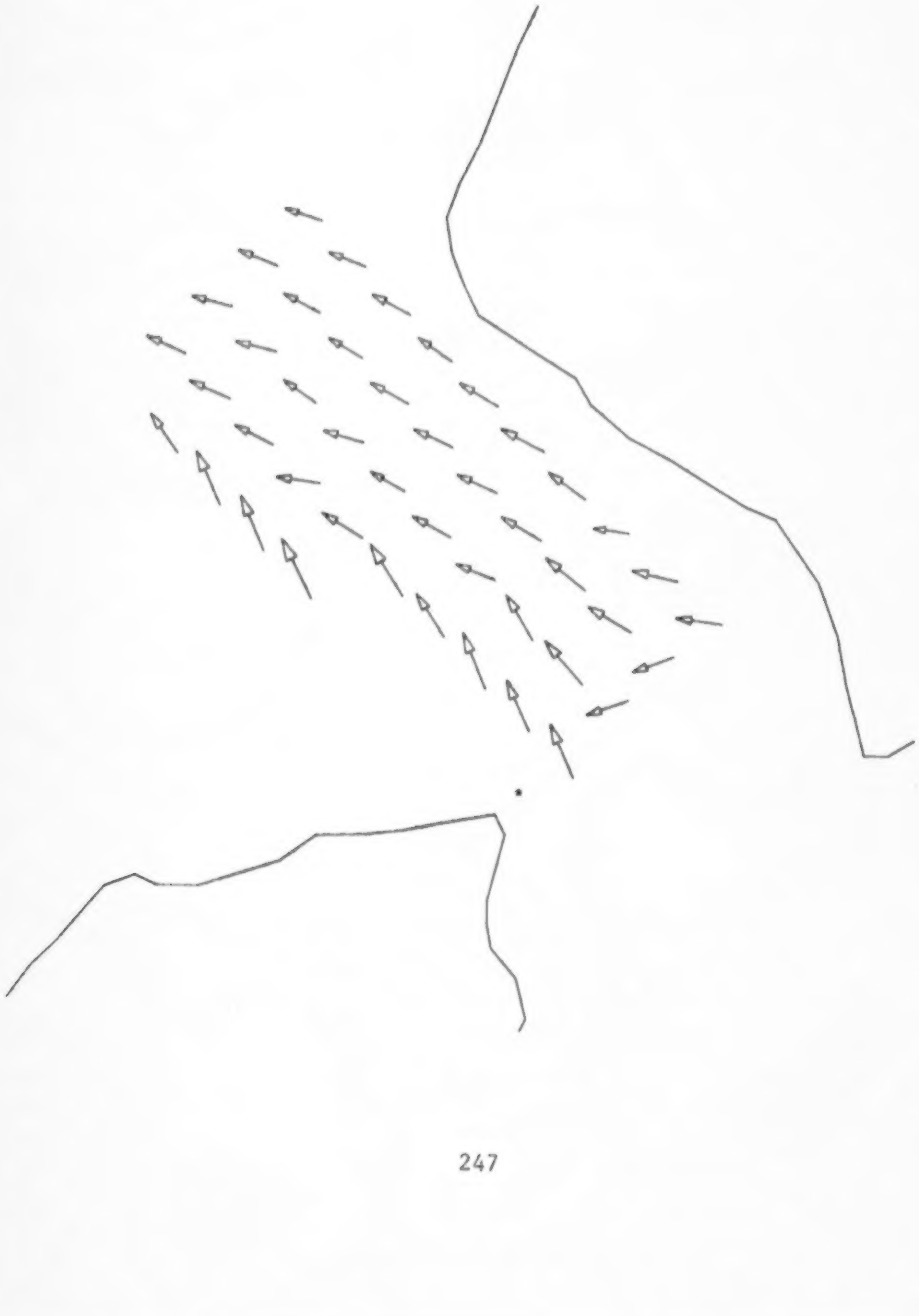
A 4.50



25 AUG 78 0: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [------------]
200 CM/S [------------]
TRUE NORTH ↑

A 4.51

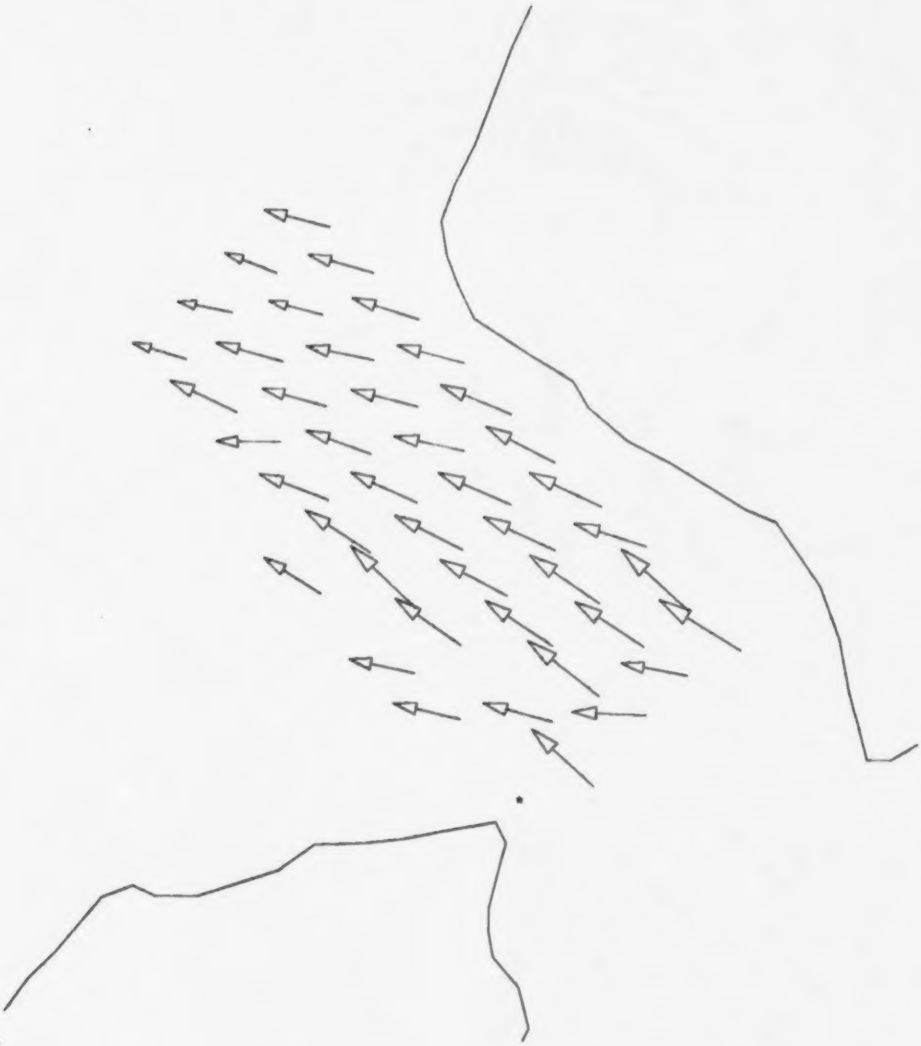


25 AUG 78 1: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [————————]
200 CM/S [————————]

TRUE NORTH ↑

A 4.52

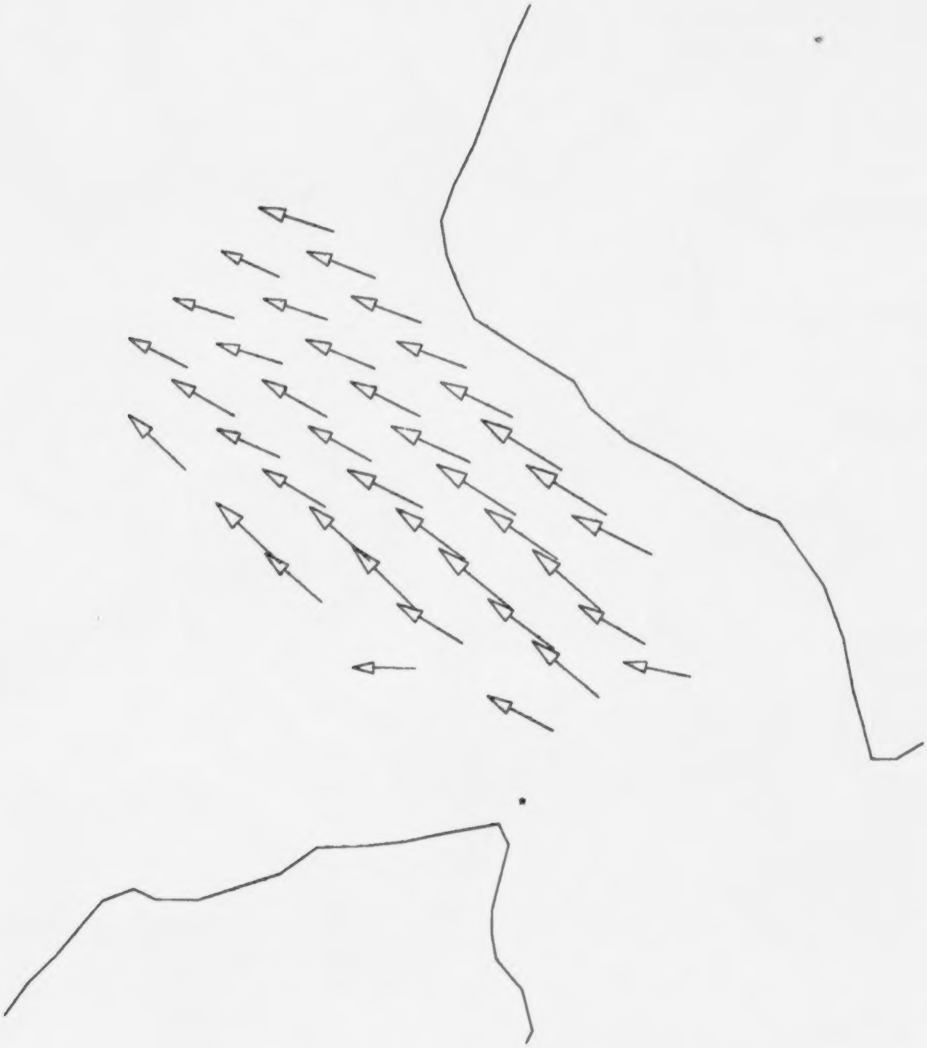


25 AUG 78   2: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [______]

TRUE NORTH ↑

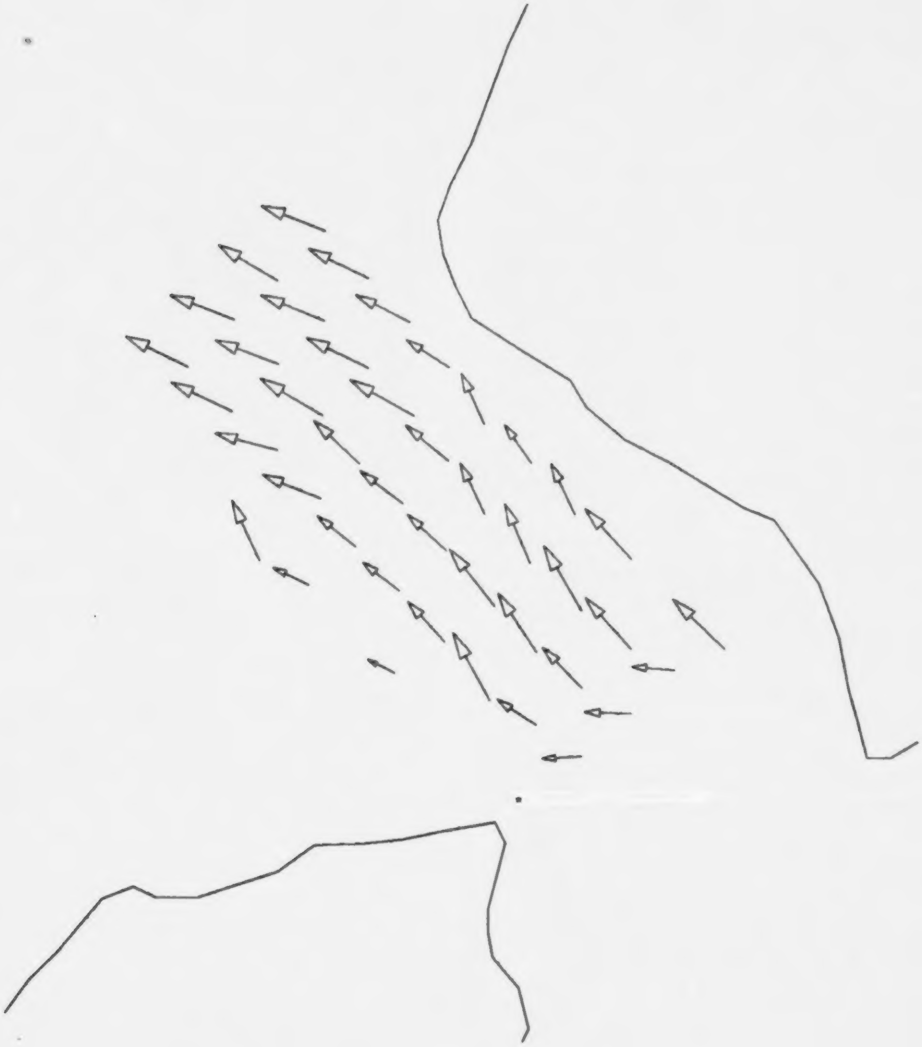
A 4.53



25 AUG 78   3: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [————]
200 CM/S [————]
TRUE NORTH ↑

A 4.54

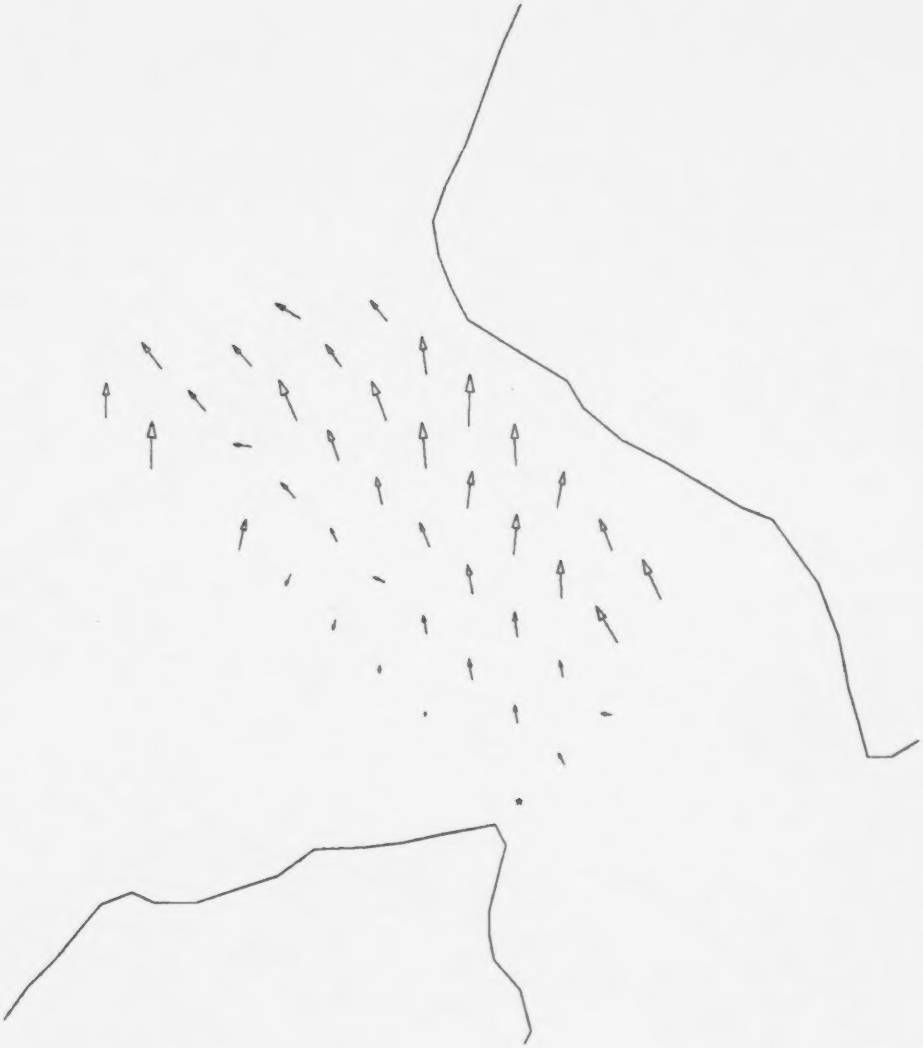


25 AUG 78   4: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

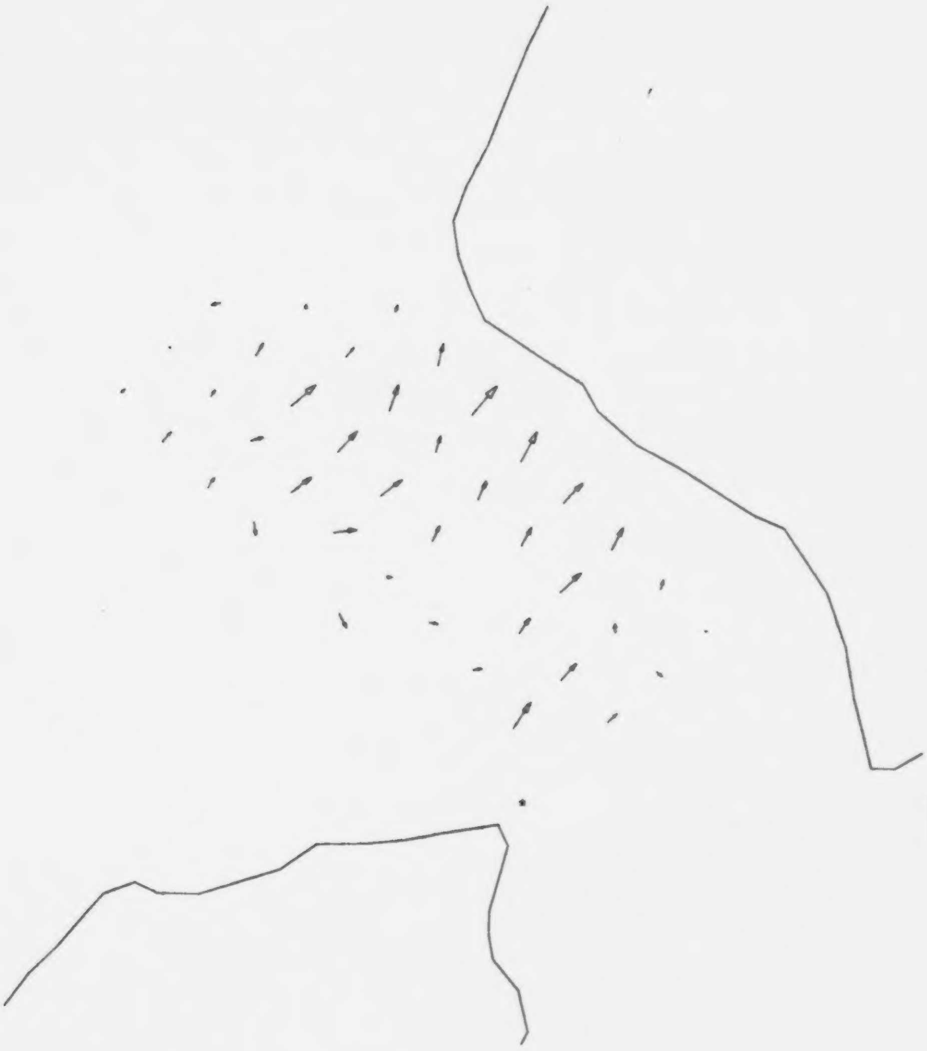
A 4.55



25 AUG 78 5: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [————————]
200 CM/S [————————]
TRUE NORTH ↑

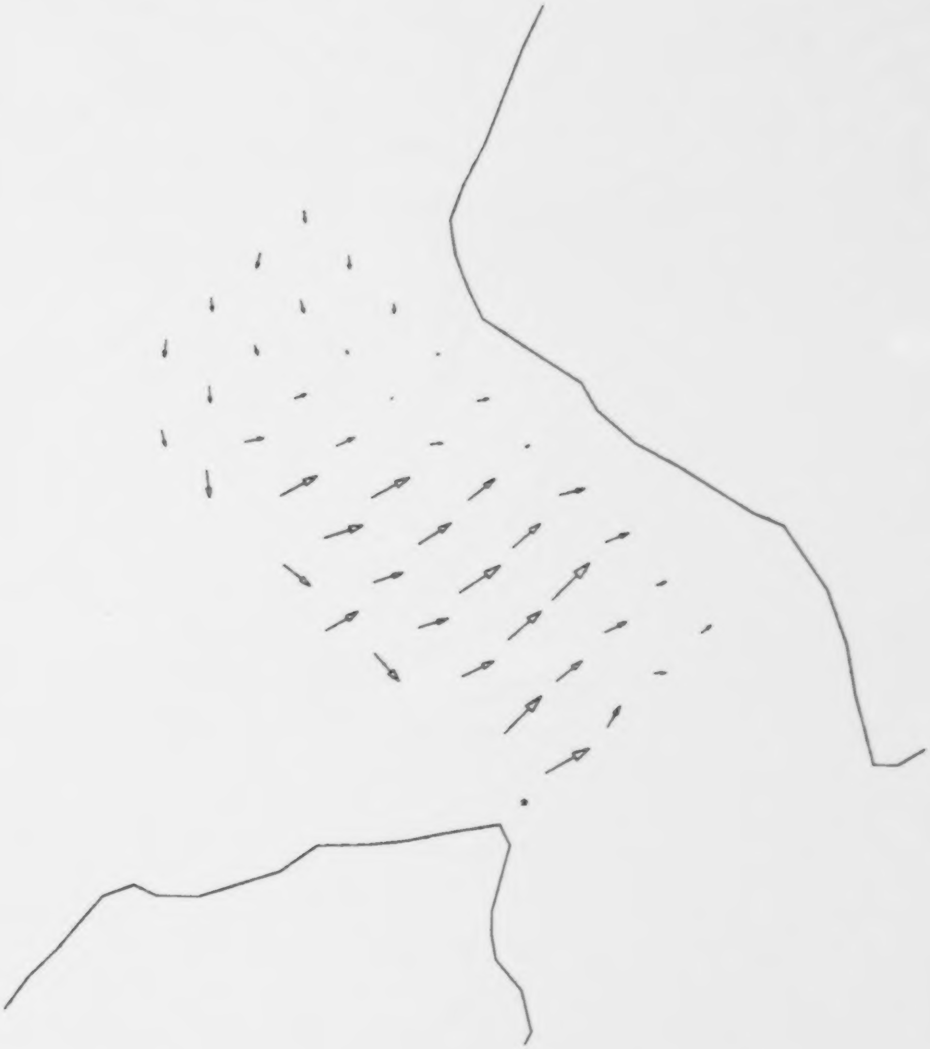
A 4.56



25 AUG 78   6: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.57

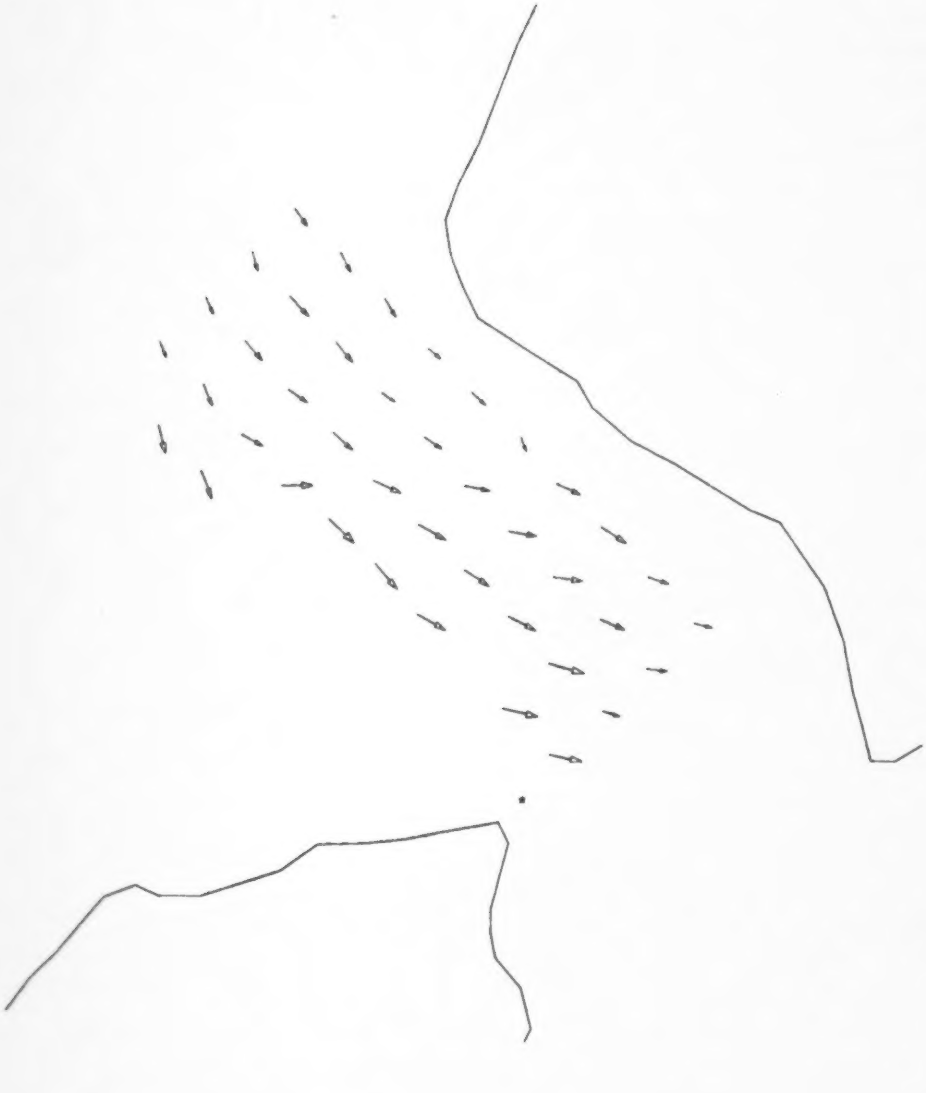


25 AUG 78 7: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [--------------]
200 CM/S [--------------]

TRUE NORTH ↑

A 4.58

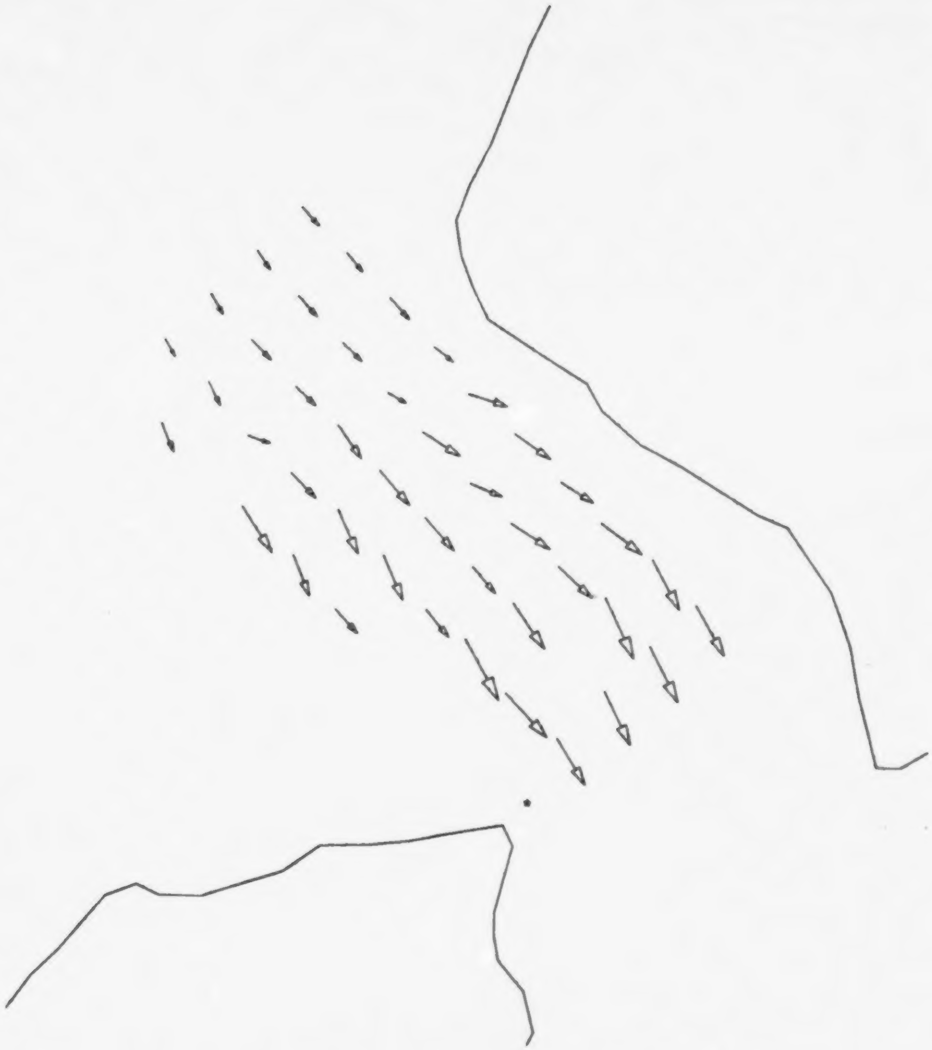


25 AUG 78 8: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

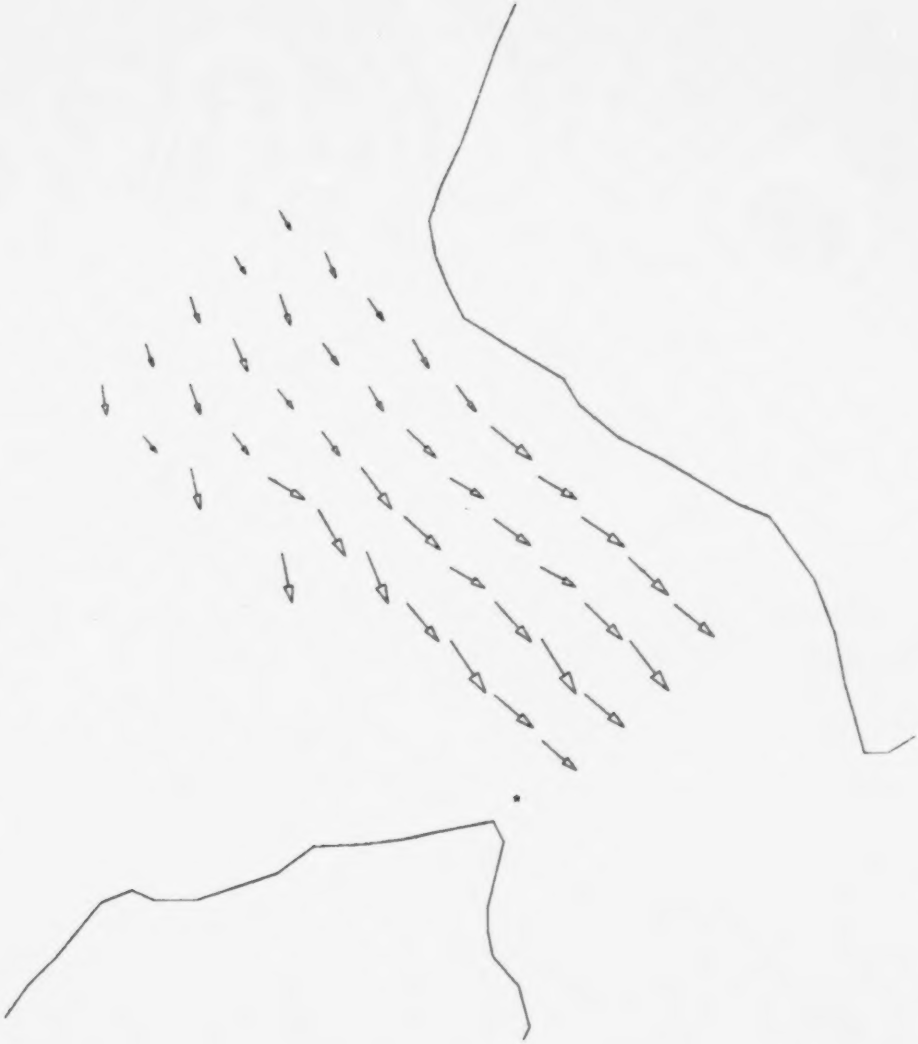
A 4.59



25 AUG 78 9: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

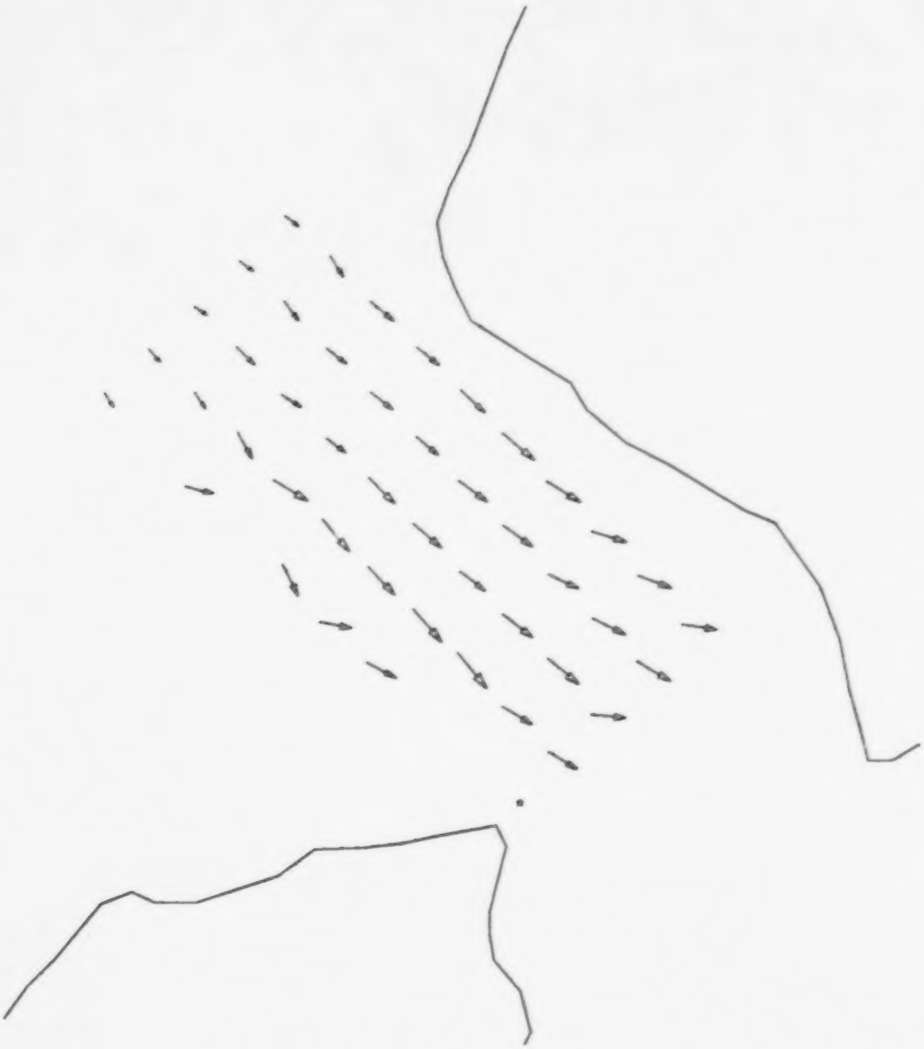
A 4.60



25 AUG 78 10: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [――――――]
200 CM/S [――――――]
TRUE NORTH ↑

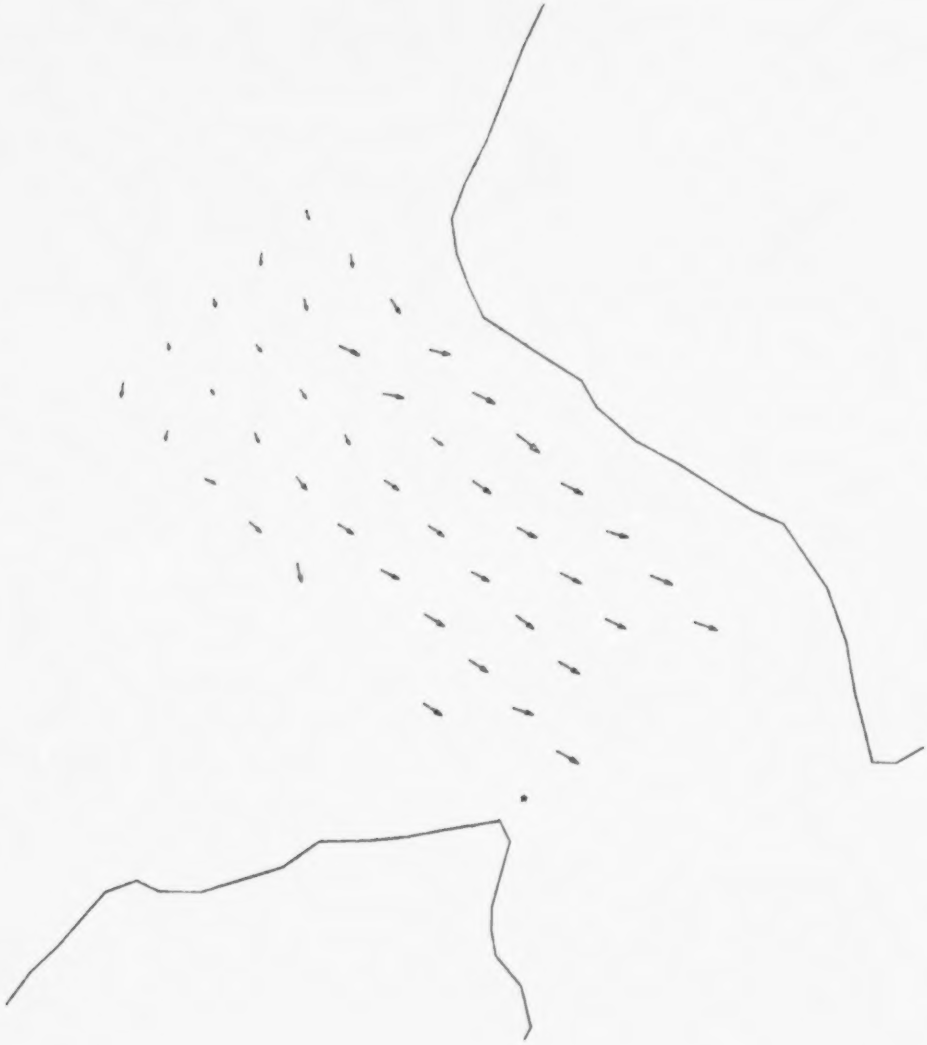
A 4.61



25 AUG 78 11: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [------------]
200 CM/S [------------]
TRUE NORTH ↑

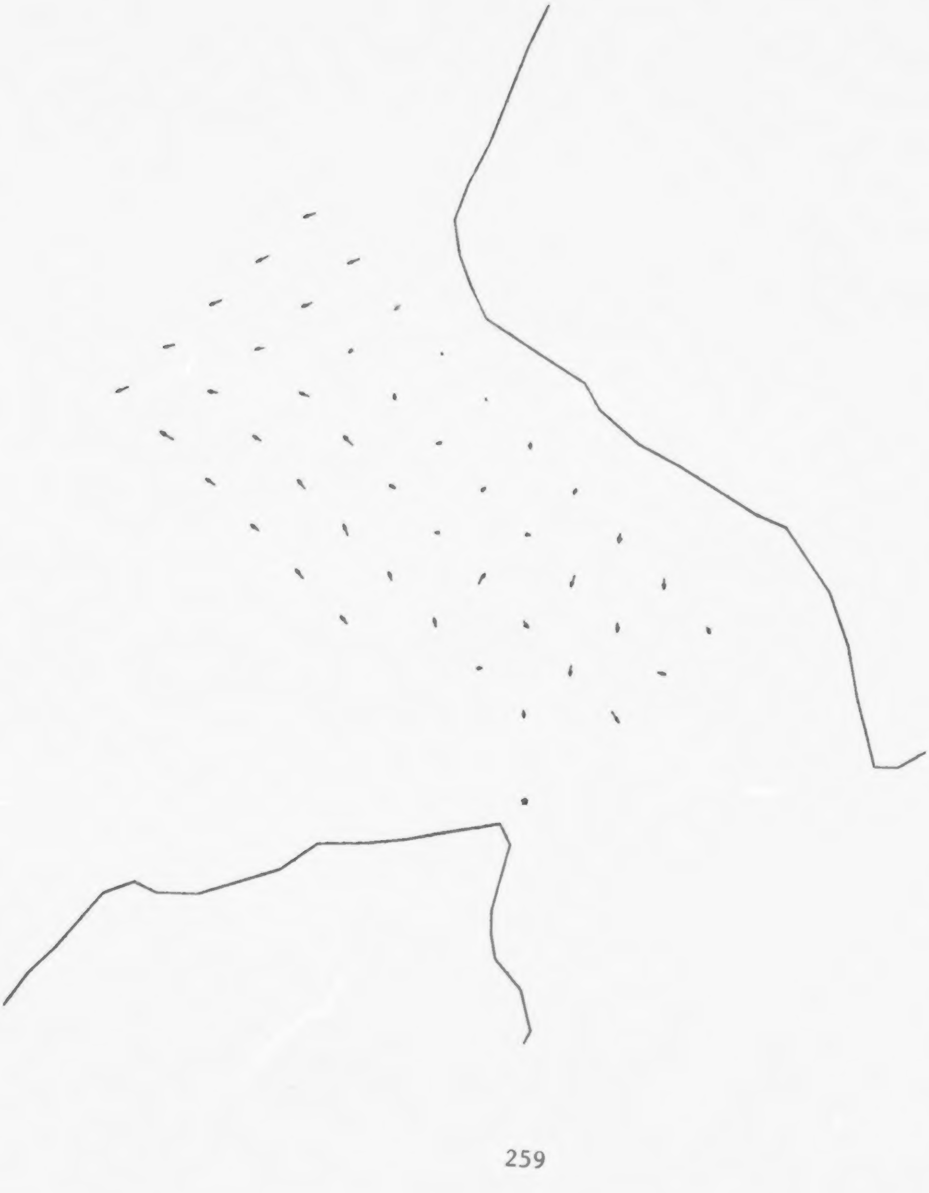
A 4.62



25 AUG 78 12: 0:00
POINT WILSON WASHINGTON
DUNGENESS SPIT WASH

2 KM [----------------]
200 CM/S [----------------]
TRUE NORTH ↑

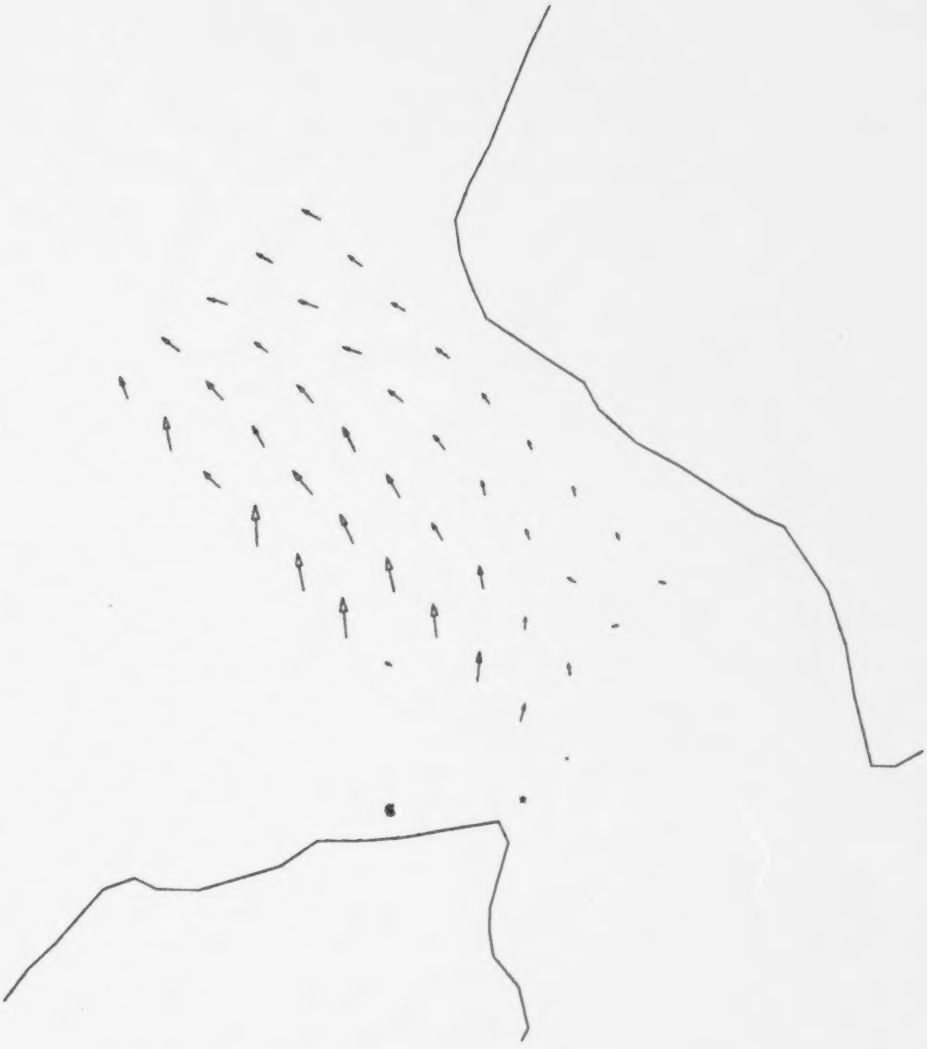
A 4.63



25 AUG 78 13: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.64

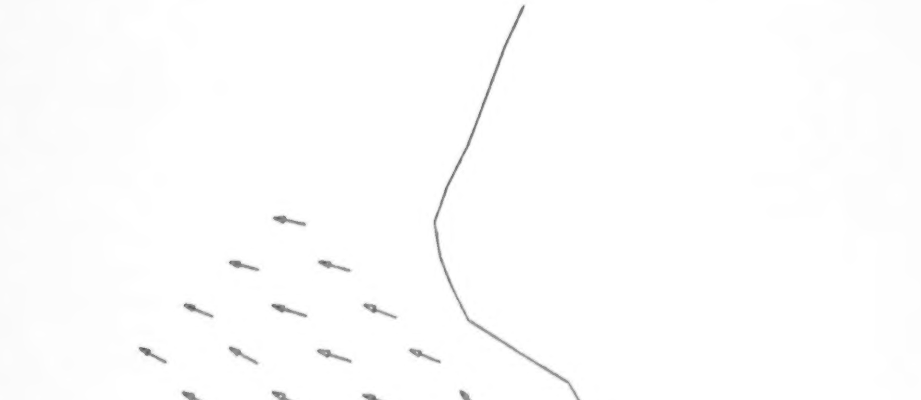


25 AUG 78 14: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [————]
200 CM/S [————]

TRUE NORTH ↑

A 4.65

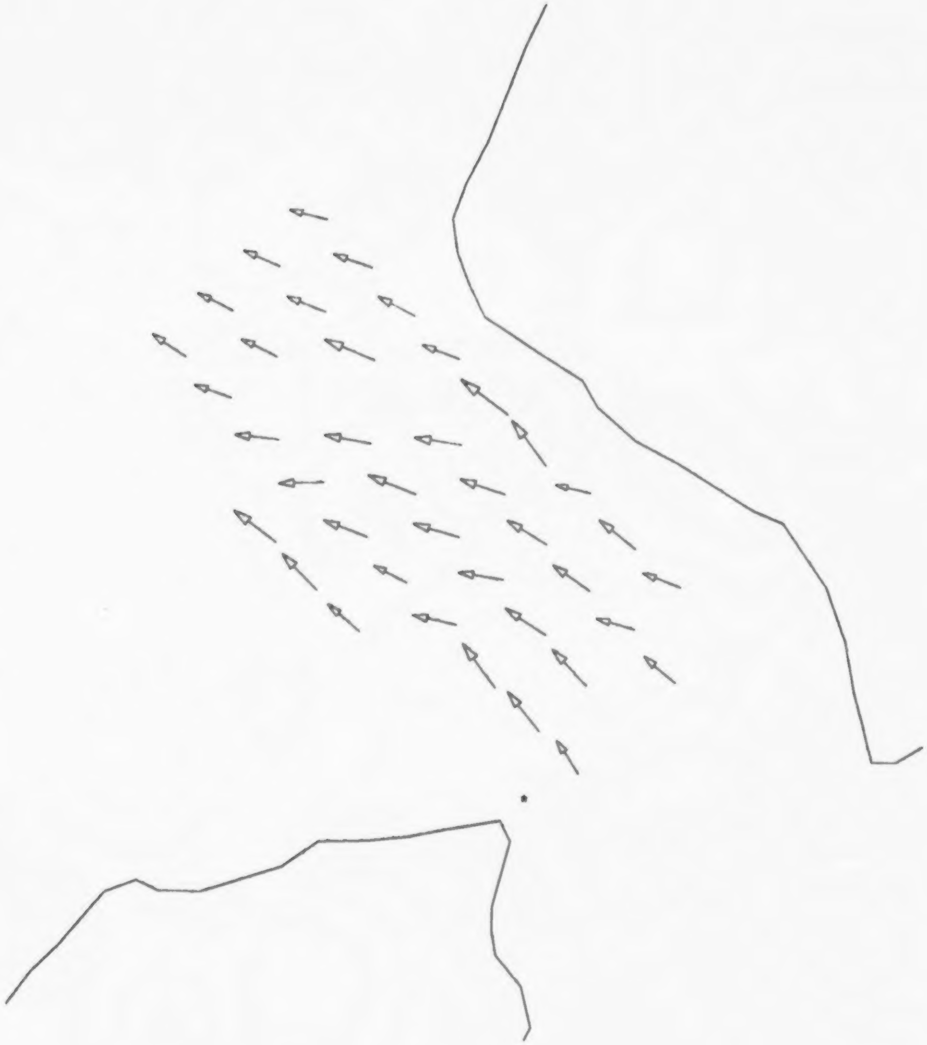


25 AUG 78 15: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]

TRUE NORTH ↑

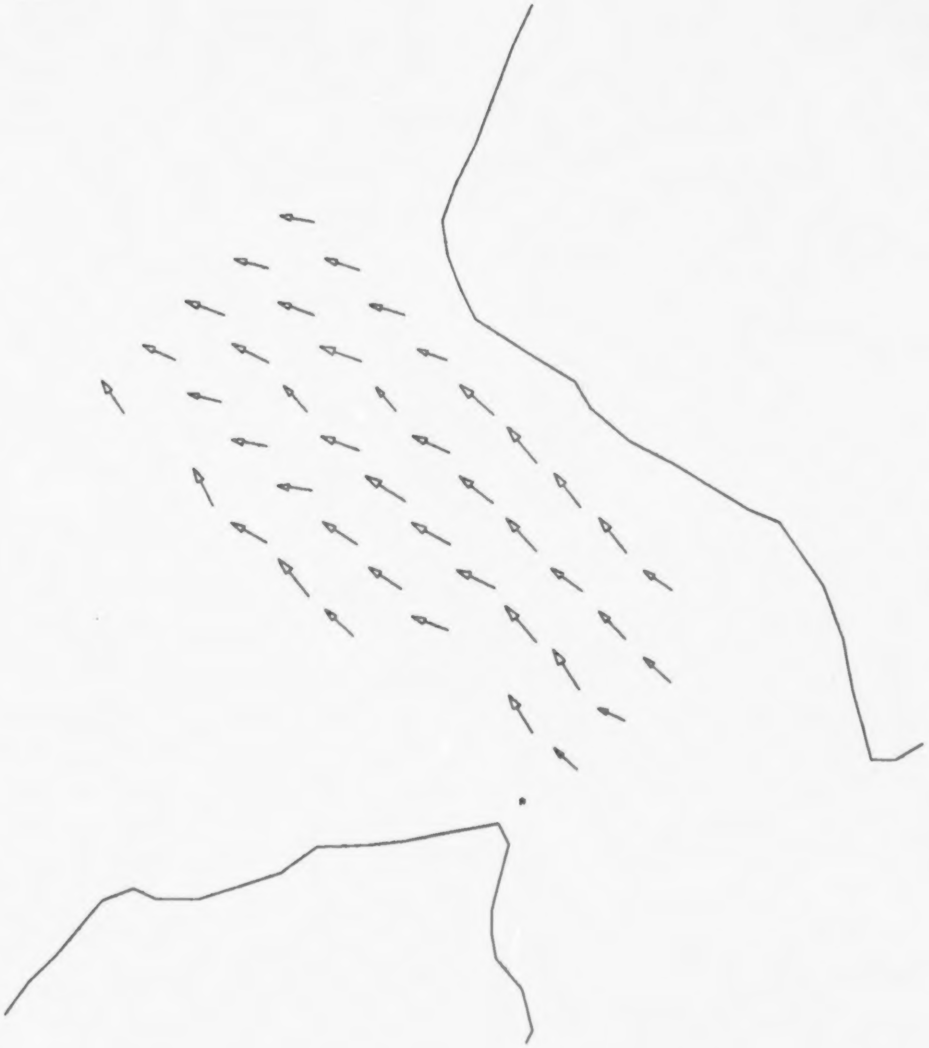
A 4.66



25 AUG 78 16: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

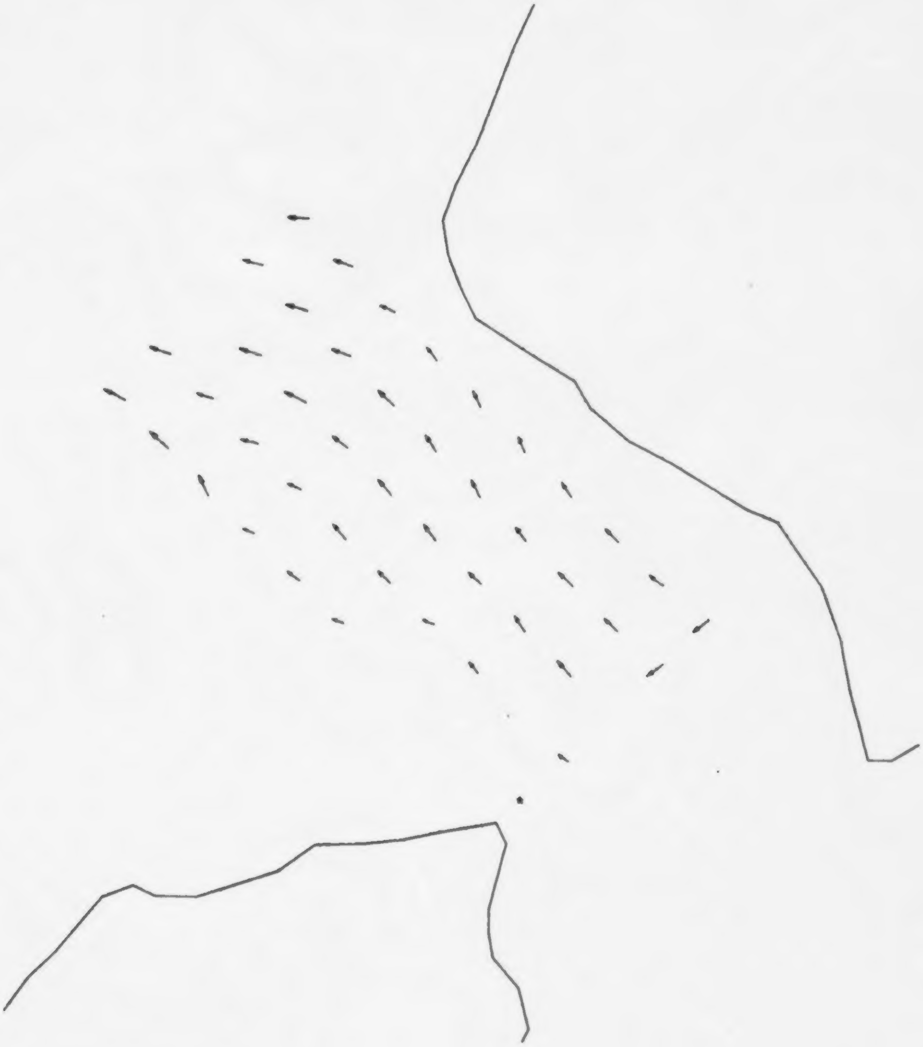
A 4.67

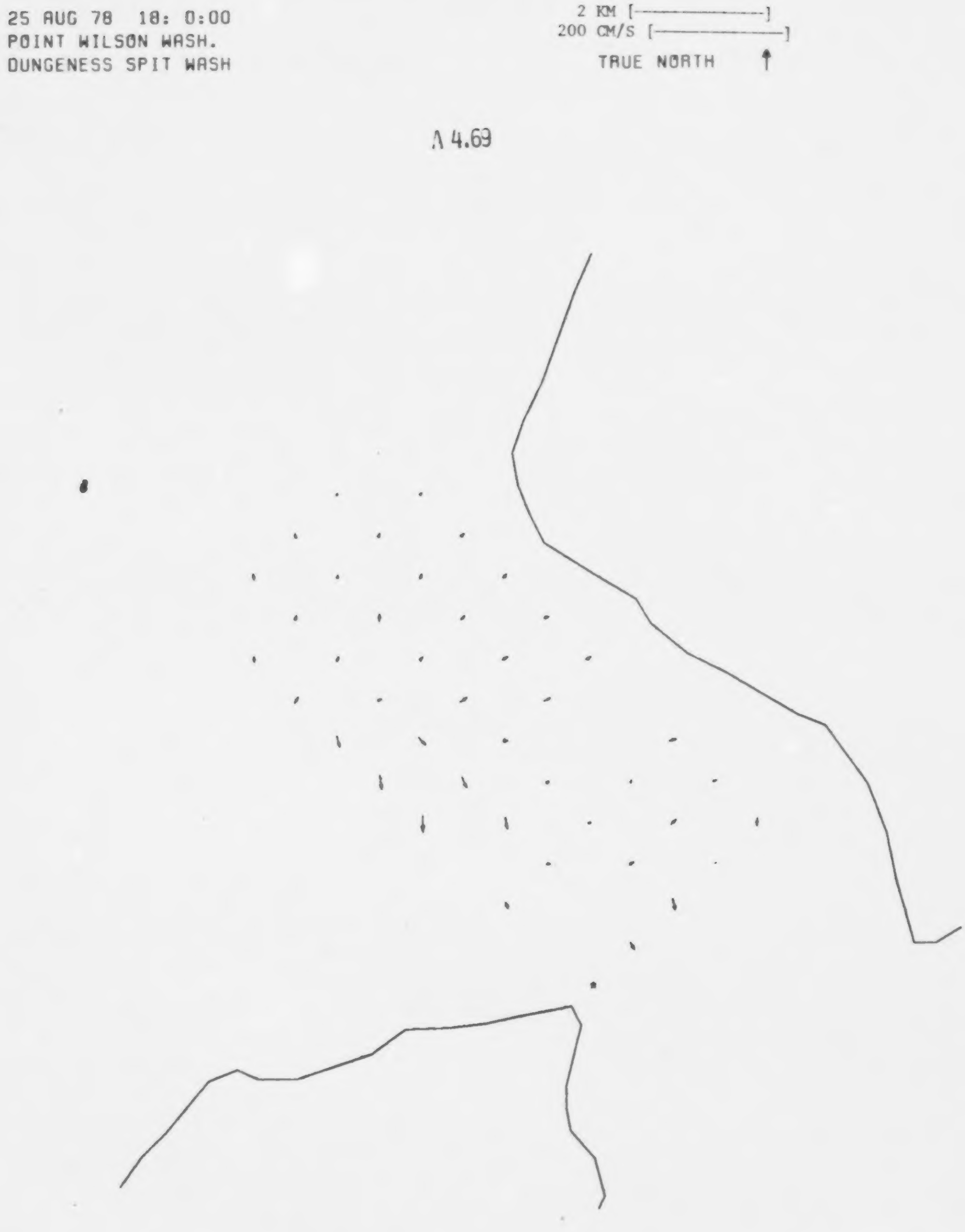


25 AUG 78 17: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.68

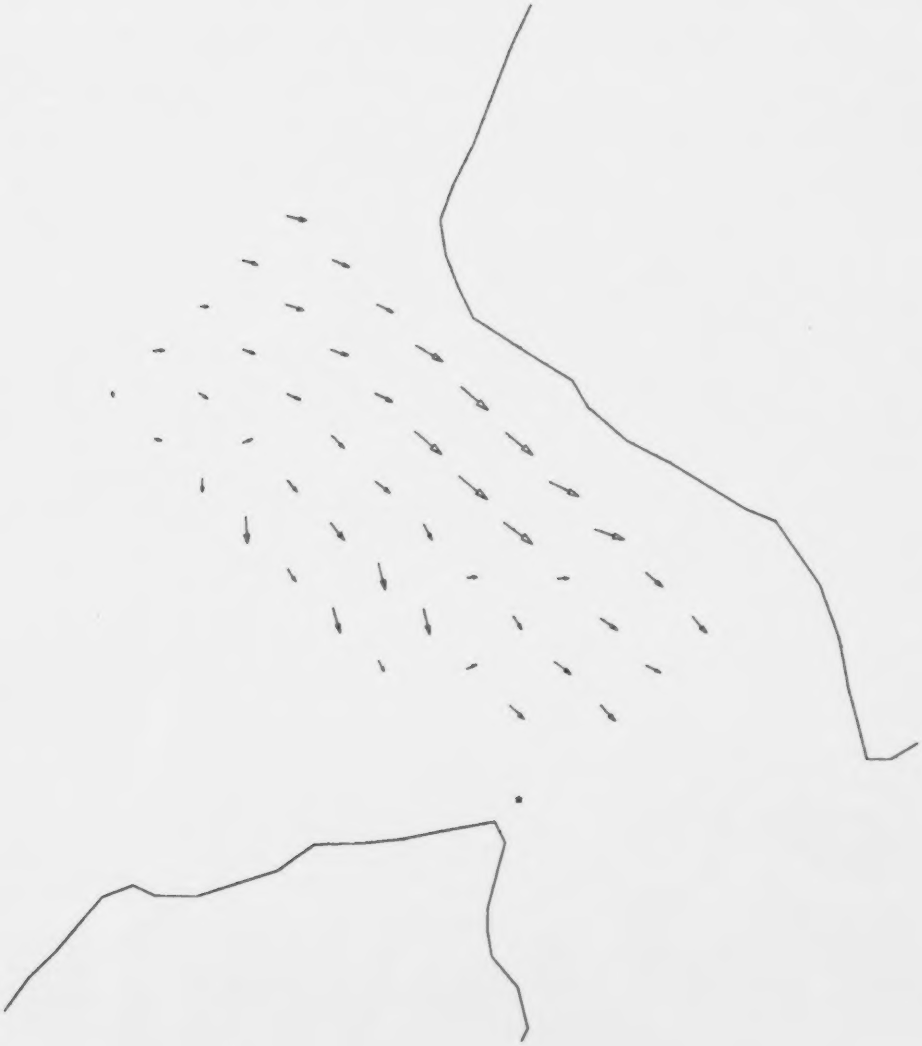



25 AUG 78 18: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH
2 KM [-----------]
200 CM/S [-----------]
TRUE NORTH ↑
Λ 4.69

25 AUG 78 19: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

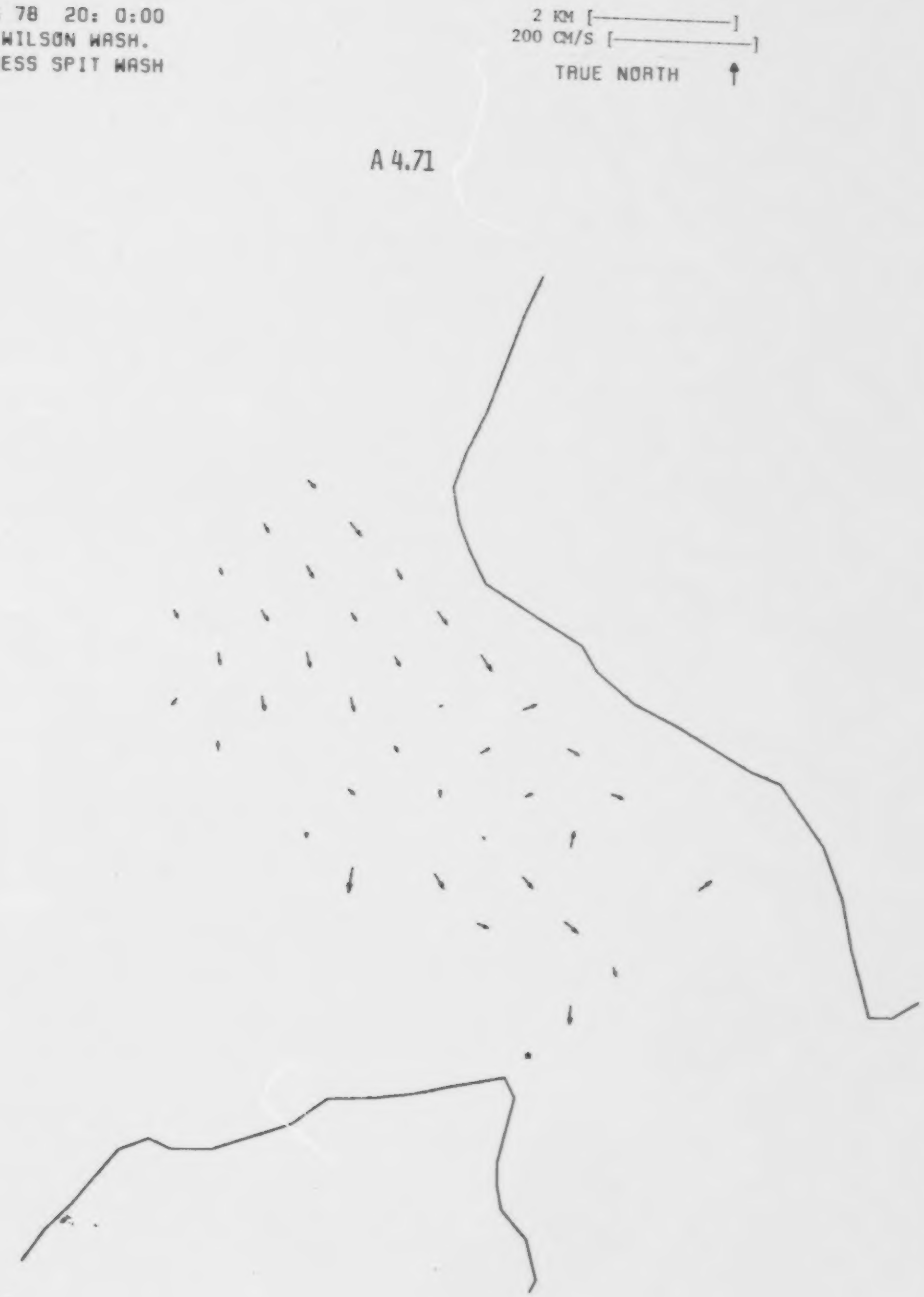
2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

A 4.70



25 AUG 78 20: 0:00
POINT WILSON WASH.
DUNGENESS SPIT WASH

A 4.71


2 KM [——————]
200 CM/S [——————]
TRUE NORTH ↑

* GPO 699-287 1980